INTEGRATED PEST MANAGEMENT PLAN

City of Grande Prairie

"Ecological solutions for a changing world."

JIM DONNELLY
INTEGRATED PEST MANAGEMENT

resourceful spirit
GRANDE prairie
growing opportunity
ALBERTA

TABLE OF CONTENTS

PREFACE

The face of pest management today is changing. Traditional broad-spectrum pesticides are slowly being phased out. Lower risk pesticides, biological control products and more sustainable cultural practices are replacing them. The industry is evolving in response to changing public attitudes and government regulations.

Municipal services must be responsive to customer needs and changing attitudes. Pest management programs must operate in a sustainable fashion and exercise fiscal restraint. They must also follow regulatory requirements under federal and provincial laws. Meeting these demands while employing urban friendly programs is the basis of this Plan.

The primary goal of Integrated Pest Management (IPM) is to provide pest management decisions based on science. To ensure the quality of these decisions IPM programs must stay current in pest management technologies, urban forestry and ecology. The Plan displays the relationship between unhealthy landscapes and pest control.

The City has a stewardship role toward the urban ecosystem. Policy needs to protect both the general welfare of its citizens and the urban environment. In this context, the Plan proposes a strategy intent on reducing the need for pest control by concentrating on prevention.

The Plan recommends an ecosystems approach to pest control and stresses the need to include our residents in this approach. The Plan Recommendations pinpoint the gaps in knowledge that need to be filled as we move towards more sustainable landscape practices.

This Plan represents the first step towards proactive plant based pest management. An Integrated Pest Management Policy and an Operational Manual are being drafted concurrently.

EXECUTIVE SUMMARY

"If we protect our environment, we protect our people."

Introduction

This Plan is about pesticide use reductions. About prevention, rather than reaction. About providing services for our customers. About protecting our green infrastructure. About ecological services. About encouraging a new landscape ethic. About meeting our federal and provincial obligations. It is about improving our urban ecology.

The Plan communicates pest control issues, outlines current pest management programs and recommends future initiatives.

The Plan focuses on both preventing and moderating pest incidence by designing sustainable landscapes, the goal being to create landscapes which require less pest control. While the Plan touches on mosquito and weed control, by far the biggest opportunities relate to improving our urban landscape health.

As the urban forest encompasses both public and private lands, improvements to urban forest health will directly benefit our customers.

The Plan will guide pest management decisions over the next ten years. Two additional documents were drafted at the same time:

Integrated Pest Management Operational Manual – A field manual for the City Arborist and IPM Technicians. An online version will be developed for homeowners and mobile devices.
Integrated Pest Management Policy – A City Policy designed to state minimum standard for City Pest management activities and its agents and contractors.

Current Program

"Integrated Pest Management is the industry standard. "

City pest management currently practices Integrated Pest Management (IPM).

IPM is a science based decision-making process that is used to decide if control is required, and if so, which combination of controls will be both effective and least damaging to the environment. Using this model results in:

- Less pesticide use
- Using least toxic alternatives
- Using Bio-control insect

- Pest monitoring programs
- Using target specific alternative products
- Increased public notification
- Staying current with industry developments

A New Direction for Pest Management

"Integrated Pest Management works, but if we want to continue improving we need to do more."

Current IPM programs reflect the baseline work required to protect the public from nuisance mosquitoes, facilities from structural pests and urban plantings from life threatening insect and disease attacks. The City has already realized all possible pesticide use reductions under the current model. In addition, under the current model, the City is not yet reaping all possible benefits from the urban forest.

To continue to protect our green infrastructure while improving our urban environment will require a new approach.

The Next Logical Step

"To improve we need to be proactive, not just reactive."

The Plant Health Care Principle (PHC) stresses maintaining plant health in order to reduce the incidence and severity of pests and disorders. The core principal being that healthy plants are better able to tolerate pest feeding. In this way, pest management would approach horticulture from a crop production point of view. Therefore, the plant and its requirements become the central focus of activities and pest control (IPM) need only be done when the plant's long-term health is at risk.

By combining this Plant Health Care principle and the Integrated Pest Management process, we will create a hybrid process that is proactive but keeps the ability to react when necessary. We are calling this model the Plant Protection Process (PPP).

Green Infrastructure or Temporary Amenity

"Shifting industry awareness. "

Traditional land development considers landscaping as the final phase of neighbourhood construction. To ensure that landscapes are built for sustainability these areas must be considered at the planning stage of the development process. This means that landscaping needs acceptance as Green Infrastructure not as a temporary amenity.

Infrastructure suggests the necessity of planned life cycles and specifications to ensure function and coexistence. For example, engineering standards and specifications exist to construct roadways, sidewalks and utilities to last for an anticipated life cycle.

City standards and specifications exist to achieve the useful life cycle for turf grass and shrubs. However, existing specifications are often inadequate for urban tree plantings.

The acceptance of urban trees as green infrastructure means that we need to ensure we have the site construction specifications in place that allow our urban forest to achieve a useful lifecycle. In addition, we must analyse our urban forest composition to ensure we maintain species that maximize environmental benefits. This means ensuring we grow a mix of trees with a priority placed on large stature, long-lived trees.

Currently 91% of our public trees are under 31 cm in trunk diameter (measured at 1.4m height). This means that it will be a few decades before these trees reach maturity and maximize their environmental benefits.

The reasons for this are many:

- Most of the large, first generation street trees planted in Grande Prairie in the 1950's and 1960's were short-lived trees (50-60 years) like Northwest Poplar and Mayday. These have reached the end of their lives and been removed.
- Rapid development cycles (boom cycles), as Grande Prairie experienced from 2000 to 2007, have seen a large number of new trees planted in new neighbourhoods. These trees will not provide full environmental equity until they reach maturity in another 30 years.
- Street trees growing in difficult site locations seldom reach maturity.

The acceptance of Green Infrastructure, and its protection, using a Tree Protection Bylaw and the Plant Protection Process, are key steps to ensuring that Grande Prairie grows a long-lived urban forest. A large urban forest, that includes many native plant species, provides the maximum amount of financial benefits and ecosystem services to the community.

Ecological Perspective

A functional food web relies on plants, animals and microorganisms that co-evolve in the same ecosystem. Plants capture the sun's energy and convert this to sugars and carbohydrates. Insect herbivores eat these plants and convert these sugars to animal biomass and decomposition products. Birds, spiders, snakes and amphibians eat these insects' herbivores. Predators eat these animals and continue to move the energy up food web.

Grande Prairie's urban forest is composed of largely non-native plant species (82%). In a typical ecosystem, up to 90% of insect herbivores are specialists that feed on only a few plant families that they co-evolved with. Few native insects actually utilize our urban forest for food and shelter. Therefore, functional food webs are few in urban centres.

Functional ecosystems rely on species diversity and species redundancy. Since our urban forest trees can't support native insect herbivores or what eats these insects, species diversity is low. Similarly, since species diversity is low, fewer organisms inhabit the same ecological niches. Therefore, there is also little species redundancy in our urban landscapes. Redundancy helps reduce the impact of periodic pest population fluctuations by ensuring that there are many different predatory insects ready to control pest outbreaks.

Most pest outbreaks that occur here are actually of non-native insects feeding on non-native plants. In general, local predators are not evolved to feed on non-native species. Some of these pests are generalist feeders that can utilize many plant species.

To create functional food webs in our urban landscapes will require planting native plant species and/or the preservation of native woodlots. These form the base of the food web that native insects require for food and shelter. All levels of consumers rely upon this base plant level for survival.

As we move towards using more plants that are native in urban landscapes, there will be more insects present. The goal is to build the landscape with enough complexity that it is self-supporting. Native insects will control native insect herbivores. Initially this will require proximity to native habitats.

A large healthy urban forest provides many environmental benefits including:

- Heating and cooling cost reductions from shading and wind blockage
- Storm water retention
- Longer lifespans on shaded asphalt and concrete surfaces
- Carbon sequestration/retention
- Reduced air pollution
- Reduced urban heat island effect and increased relative humidity
- Lower crime rates
- Reduced pesticide use
- Wellness opportunities and increased community spirit

A large healthy urban forest that includes many native plant and animal species provide the above benefits and ecological services such as:

- Helping maintain biodiversity by connecting native habitats within the urban centre
- Building ecosystem redundancy
- Reduced childhood nature deficit disorder
- Attracting native animals such as beneficial insects, songbirds and squirrels to our yards
- Creating habitat for low level predators

Transitional Steps

"Going from theory to practice."

"The New Operational Model!"

Plant Protection Process (PPP)

- Merges Plant Health Care with Integrated Pest Management
- A prevention-first philosophy
- Less pesticide use on public and private lands
- Longer lived trees = more associated benefits
    - more storm water diversion
    - lower heating and cooling costs
    - a larger, healthier urban forest
    - better air quality
    - higher carbon sequestration
    - higher property values
    - lower health care costs
- Higher tree survival = lower tree replacement and associated costs
- Lower pest management costs

From an urban planning perspective, each tree that reaches maturity provides an average of 17 times as many tangible and intangible benefits as a newly planted tree. Initial research indicates that every $1.00 we spend on urban trees yields $2.77 in benefits to our Community.

Our urban forest has an assessed value of about $20 million. This assessed value grows as the tree stature grows. If all of our young trees grow to maturity this asset value would appreciate 5 - 10 fold.

"Helping Our Customers?"

Public Education Programs

- Communicate a new Landscape Ethic:
    - which recognizes that plants are insect habitat and that this in natural
    - which encourages the wise use of native plants to augment non-native ornamentals
    - that backyards can become functional biological communities that connect our children with nature
    - which understands that the establishment of local food webs can replace the need for many pesticide applications
- By teaching landowners sound horticultural techniques, we will start to mirror our initiatives on private lands.
- Existing survey work has already established that public attitudes are ready to adopt some of these changes.

"Do the Science!"

Recommendation Items

- Research needed to ensure that proposed changes are valid for our local conditions. To do this local soil and site condition analysis is required
- Assess the Design and Construction Manuals landscape standards based on our research. Proposed new standards need to include:
    - maximum allowable soil compaction standards (bulk density) in the planting areas
    - uncompacted soil per tree specification

Early research indicates that some urban soils are compacted past the point at which plant roots can penetrate them. More information is needed to determine where conflicts exist and find solutions.

Changing Focus

"Focus on the causes, not on the symptoms."

Most urban trees do quite well, however some improvements are needed to produce sustainable tree growth at challenging sites. Urban trees that reach maturity have extensive roots systems and energy reserves to bounce back from moderate feeding pressure.

Current construction practices can create compacted soils and predispose street trees to pest attacks and disorders. While City topsoil standards exist, there are no existing subsoil standards to prohibit root-limiting compaction at tree planting sites.

Tree planting sites/survival rates:

- Inner city trees in concrete cut-outs: low survival
- Highway boulevard and planter strip trees: low survival
- Neighbourhood parks moderate to high survival
- Collector road separated boulevards moderate to high survival
- Residential lot frontage high survival

Low soil moisture, inadequate soil volume and soil compaction are the major limiting factors to growing trees in this region. By moderating these limiting factors, urban trees will be healthy enough to tolerate most pest feeding. This will result in less pesticide use. This is the application of the Plant Health Care Principle.

This is a major philosophical change in thinking. The value of this change will need to be effectively communicated. Acceptance of these changes will require extensive consultation and negotiation.

Financial Implications

"The cost of sustainability."

Labour resources were compared to existing workloads to determine sustainability.

Assessed Criterion:

- Do existing resources meet existing workloads?
- Can resources be reallocated to fill gaps?
- Will initiatives under the Plan require additional resources?
- Can reorganization fill the labour shortfalls?
- Will annexation of lands during the 10-year relevance period of this plan require additional resources?
- Are there requirements for formal education and specialized training?

It was determined that some existing programs are currently under-resourced. In addition, more resources will be needed to implement the proposed recommendations from this Plan (full breakdown on page 76).

It was determined:

1. That some existing programs are currently under-resourced and not sustainable under the current framework.
2. That some valuable programs have been dropped to free up resources for priority work.
3. The IPM work unit is already streamlined for efficiency and flexibility. While minor time efficiencies are possible by increasing the amount of equipment, no further large time saving can be achieved, short of dropping programs.
4. That implementing the IPM Plan research items cannot be undertaken with existing resources.
5. That work related to private pest problems should continue, as these are opportunities to serve our customers and to communicate our program goals.
6. That the technical unit requires:
    a. technically inclined individuals with formal education in horticulture, entomology, agriculture or forestry
    b. lab and field work experience

    Running technical programs with seasonal workers is impractical.
7. That pesticide applicators and authorized assistants undergo extensive training and provincial testing. It is against provincial regulations to use temporary labourers without first providing extensive training.

Recommended Labour Additions: (see page 74 Recommendation).

1. 1 fulltime IPM technician position
2. 1 seasonal Weed Inspector
3. 2 seasonal Pesticide Applicators

Equipment Summary:

1. No capital equipment purchases through 2018.
2. One existing fleet sprayer and truck be repurposed to accommodate staff increases.
3. Small engine equipment will be purchased out of operating budgets.

Pesticides Summary:

Goals:

1. Reduce pesticide use
2. Reduce pesticide toxicity
3. Retain efficacy
4. Reduce environmental footprint

- At this time, there are no new bio-herbicides available for purchase.
- Bio-herbicides, though usually very expensive, should be trialed to determine efficacy, cost efficiency and suitability for municipal operations.
- Several bio-control agents for the control of Common Tansy are currently being assessed for registered use in Canada. Once these pass registration, we expect to be able to do controlled releases of these insects. Bio-control agents feed on noxious weeds and can result in reduced pesticide use. Following release population density and distribution is tracked to determine insect survival and success.
- One upcoming product utilizes the fungi *Phoma macrostoma* to control broadleaf plants. If this trial were successful, City IPM would have an environmentally friendly product to use on noxious weeds. Once the product is for sale, testing will take one to two years.

Public Opinions Survey

"Environmental awareness is increasing."

- 190 respondents had a reasonable understanding of basic pest issues. *2012 City of Grande Prairie Pest Management Survey summary page 90.*
- 93.5% of respondents indicated that they do not believe that chemical pesticides are required to maintain a healthy lawn.
- 76.1% of respondents indicated that pesticides should only be used on lawns when other methods of pest control have failed. These responses likely indicate strong convictions about what should be used on home lawns.
- 65% of respondents replied that it was very important or important that City green spaces be weed free. This result is at odds with the results from the 2012 Parks Masterplan question in which 62.2% of respondents either agreed or strongly agreed to City Councils decision to discontinue cosmetic dandelion control on (the majority) of City green spaces. The Parks Masterplan response must be viewed as more statistically credible given that there were double the number of respondents.
- 51.1% of respondents indicated that the City of Grande Prairie did not need a bylaw restricting pesticide use, while 48.9% of respondents indicated it did. This result could be indicative of changing urban attitudes.

Issues Related to Public Perception

"Let's go to them."

Public Relations:

Pest management activities are timed to take advantage of calm weather conditions and to minimize impact to our customers. This, however, means that pest management operations are seldom seen and poorly understood.

Implementing the changes suggested in this Plan will require a new focus on public relations and education.

Transparency

- Operating in such a way that it is easy for others to see what actions are performed.
    - More visible application signage
    - Increased public notices

Profile

- Being a primary source of accurate pest management information for our customers.
    - Use of traditional and social media tools to engage our customers
        - Not just about pests on public lands but what's in their back yards
    - Increased public education programs
        - Sustainable landscape design principles that encourage beneficial insect presence

A Pest Management Resource

City IPM fields about 200 calls from homeowners seeking advice on private plant or pest related problems each summer. With increased media exposure, we expect that this number will increase substantially.

    - Branding City Pest Management for consistent messaging

To influence change on private lands the City will need to become a highly visible pest management leader in Grande Prairie.

Future Projections

"These could happen."

Over the **10-year relevancy period** of this Plan, expectations are:

- Grande Prairie's average temperature may increase by about ~0.4°C Analysis of Alberta Temperature Observations and Estimates by Global Climate Models 2000
- Much of the anticipated temperature increase will be in the winter and spring.
- Traditional pest ranges will continue to expand north on the prairies.
- During proposed annexations Grande Prairie Municipality will grow dramatically; however, pest management costs will increase in step with land development not with municipal borders.
- It is unlikely that Grande Prairie will suffer another multi-year drought.
- New organisms will arrive in Grande Prairie and some of these will be regulated invasive alien species and require control.
- Environmental health will continue to be important to our residents.

List of Recommendations

SCOPE OF PLAN

- This Plan will have both an ecological and pest management focus.
- The IPM process requires an understanding of the cause and effect resulting from pest management decisions. The focus must be, not just on the targeted pest, but also on its surroundings.
- The City of Grande Prairie is required to manage pests regulated under provincial and federal legislation. This Plan will therefore need to consider local and large-scale issues.
- This Plan will provide the knowledge required to understand the reasoning behind the recommendations.
- This Plan will shift the reader's paradigm away from pest management as separate from ecology.

The Integrated Pest Management Plan will:

- Start the move to proactive ecosystem management (move away from dealing with pests as reactive incident-based events).
- Integrate the following management processes into an inclusive method called the **Plant Protection Process**.
    - Plant Health Care Process (stresses the maintenance of plant health to prevent or reduce pest incidence).
    - Integrated Pest Management Process (targets pests attacking people and infrastructure).
- Lead to the development of an IPM Manual of Best Practices to guide management operations on public lands.
- Understand how local pest management actions relate to national interests and the larger issues of the ecosystem.
- Address our current pest management programs.
- Set the course for pest management programs in Grande Prairie.
- Make recommendations for future work.

ROLES AND RESPONSIBILITIES

1. The Integrated Pest Management Coordinator is required to implement the Integrated Pest Management Plan and report to the Community Living Committee.
2. The City Manager has ultimate authority over the Plan and cedes this authority to the Parks Operations Manager for supervision.
3. City Council affirms their support of this Plan by its adoption.

The mandate of this Plan is on municipally owned lands.

BACKGROUND

THE ENVIRONMENT

There are an estimated 8.7 million species of organisms on our planet. In reality, no one really knows with certainty as most of the earth's organisms have yet to be scientifically named and studied. This means that science does not have a complete understanding of our world's ecology and how all the pieces come together. By extension, any pest management operation must assess the need for control against their general lack of ecosystems knowledge. A precautionary approach will minimize non-target impact.

Species Worldwide

- *250,000 - 400,000 angiosperms (flowering plants)*
- *15,000 species of ferns and their allies*
- *1,000 species of gymnosperms (conifers and relatives)*
- *75,000 species of fungi (exponentially more not yet named)*
- *23,000 mosses*
- *1 million species of insects listed by science (exponentially more not yet named or studied)*
- 28,000 *species of fish*
- *10,000 birds*
- *5,400 mammals*

Species in Alberta

The 2010 edition of the "General Status of Alberta Wild Species" shows 5235 species in the province. This number includes plants and animals (not microorganisms). This number does not include un-named non-catalogued species.

Species in Grande Prairie

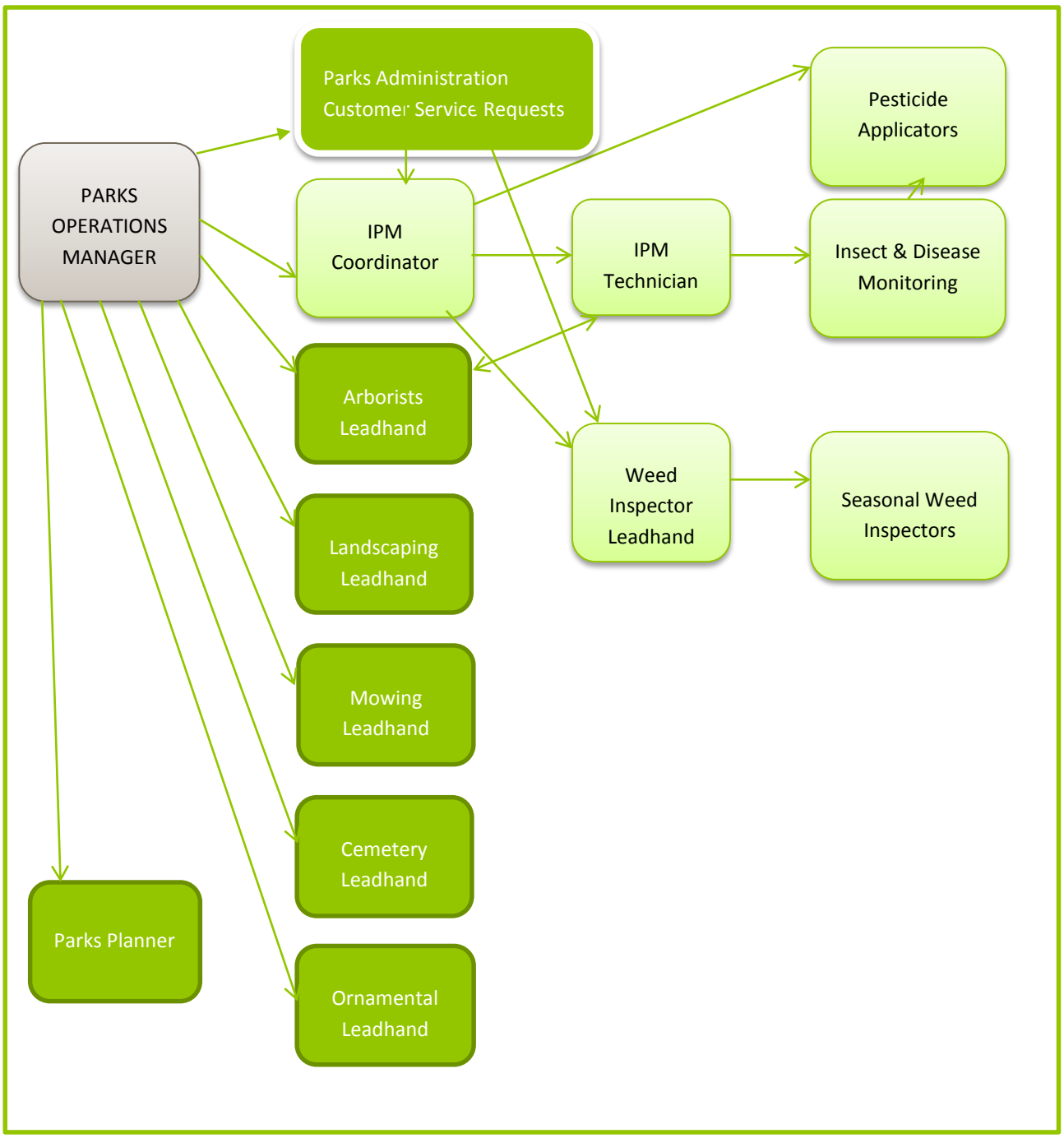
We can expect that local species will be those that are native to boreal forest, parkland, grassland ecotypes, or non-native species introduced from similar or compatible ecotypes.

THE MOVE TO INTEGRATED PEST MANAGEMENT

Table 1. Evolving Pest Control in Grande Prairie

Date	Advancements
1994	City creates a contact list for Customers with allergies to pesticides
1996	Most programs used traditional pesticides. Some insect monitoring, no formal thresholds
1997	**Decision to move to an IPM approach**
2000	Transition to least toxic alternatives starts Beneficial Insect release program starts
2003	Seasonal Insect Technician hired Insect and disease monitoring programs start Establishment of first pest thresholds
2004	100% Biological mosquito program established Testing and trials of existing biological control products
2006	Weed Inspector hired
2008	City Council votes to discontinue dandelion control program
2011	Permanent Insect Technician hired
2013	Integrated Pest Management Policy, Plan and Manual created

CURRENT PROGRAM ORGANIZATION



Integrated Pest Management Staff

The Integrated Pest Management work area is comprised of three work units:

Technical Unit
Pesticide Application Unit
Weed Inspection Unit

Under the current operational structure:

- The IPM Coordinator manages all financial, regulatory and operational aspects of pest management for the City of Grande Prairie, as well as customer service.
- The Insect Technician performs insect and pathogen monitoring and is responsible for the application of the Agricultural Pests Act of Alberta.
- The Weed Inspector Leadhand is responsible for the application of the Weed Control Act of Alberta and daily supervision of the seasonal weed inspectors.
- The Pesticide Applicators control noxious class weeds as directed by the coordinator.

Workload Implications

- Grande Prairie municipal area has increased by 17% over the last 15 years. Municipal infrastructure has increased in step with development.
- 2013 Asset Inventory statistics:
    - 20,736 trees on public lands
    - 12,458 square meters of shrub bed plantings
    - 1348 square meters of flower bed
    - 199 mosquito development sites
    - 522 hectares of turf grass
- Current pesticide application staffing levels do not meet current workloads
    - Current staff levels are already working at capacity. Additional noxious weed control work resulting from new development or annexation will require increased staff and equipment levels to meet our obligations under current legislation (pages 61-75).
- Current Technical staffing levels do not meet current inspection and control workloads
    - Under the Agricultural Pest Act of Alberta, additional municipal obligations have been outlined on the document “Alberta Dutch Elm Disease Prevention/Control measures”. City IPM will implement these measures in 2015.
    - Implementation of the proposed Plant Protection Process model will require additional pest monitoring on public lands and additional public education programs for local landowners. This work will fall to the technical unit.

- Proposed Annexation
    - If annexation occurs City pest management will incur increased maintenance obligations. Annexation impacts are expected to immediately affect these two program areas:
        - Noxious Weed Inspection and control operations
        - Mosquito monitoring and control operations
    - The rate of development is dictated by economics. Therefore, these pest management activities that are tied to development will grow as development occurs, rather than with annexation:
        - Urban forest pest management
        - Bare ground vegetation management
        - Broadleaf weed control on Class A irrigated turf grass (currently 20-30 hectares annually)

Regulatory Requirements: City of Grande Prairie

Alberta Environment regulates all pesticide businesses in the province. Under the Environmental Protection and Enhancement Act (EPEA):

A Pesticide Service Registration is required if:

- It offers or provides a service involving the use or application of a pesticide in Schedule 1, 2, or 3 for hire or reward
- It uses or applies a pesticide on a right-of-way
- **It uses or applies a pesticide in a park, boulevard, campground or picnic area that belongs to a federal, provincial, municipal government or other local authority**
- It uses or applies a pesticide for forest management.

The City registration number is 11404-02-00 in the following classes:

1. Agriculture
2. Industrial Vegetation
3. Aquatic
4. Greenhouse
5. Landscape
6. Biting Fly
7. Special: Interior Plantscape

The Act also requires the City of Grande Prairie employ a certified pesticide applicator with the same certification classes listed on the Service Registration. Currently the Integrated Pest Management (IPM) Coordinator holds these classes of certification.

In addition, the Weed Inspector Leadhand and the IPM Technician are certified in:

1. Landscape
2. Industrial
3. Biting Fly

These individuals infill the Coordinator position during vacations and absences.

A NEW DIRECTION FOR PEST MANAGEMENT

Crystal Lake in Grande Prairie

GUIDING STATEMENTS AND PHILOSOPHY ALIGNMENT

Over the last decade, the City of Grande Prairie has moved from traditional pest control operations to an IPM model. This move has resulted in pesticide use reductions and a healthier, more sustainable urban environment.

To achieve further reductions and continue to protect the health of our urban green spaces, we will need to embrace new philosophies and methods. The Plant Protection Process is one of these philosophies and is aligned with our citizens needs and with our corporate values.

The majority of the developed land within Grande Prairie is privately owned. We will need to create public education campaigns to encourage public adoption of our environmental philosophies.

These campaigns will promote:

- a more holistic, connected view of our urban environment
- environmentally friendly pesticide alternatives
- the prudent use of pesticides
- habitat protection
- the need to manage invasive alien species

COUNCIL VALUES 2012-2014

"Our policies and decisions are environmentally sound. We consider the impact of our actions on the environment and lead by example."

"A focus on healthy living along with community safety is integral to our well-being."

MUNICIPAL DEVELOPMENT PLAN

"To embrace opportunities for protecting the natural environment in the urban context."

MUNICIPAL SUSTAINABILITY PLAN

Our Preferred Future …

"We are a beautiful and sustainable community that provides an exceptional quality of life to its residents and is the core of a prosperous and dynamic region. Our residents are connected to the environment and are aware of the environmental impact of their decisions. Our parks and open spaces enhance the quality of life for all."

PARKS OPERATIONS MISSION STATEMENT

"To enhance and protect the parks and open spaces essential to personal and community quality of life and environmental health."

THE NEXT LOGICAL STEP

The next logical step is to incorporate the Plant Health Care principle into our pest management and maintenance programs. By combining the PHC Principle with the IPM Process, we have created a Plant Protection Process (PPP).

PLANT PROTECTION PROCESS

TABLE 2. PPP

PLANT HEALTH CARE PRINCIPLE refer to page 43	
1. DEFINE PREVENTATIVE MEASURES	
	Host Identification
	Host Growing Requirements
	PIC Cycle
TRADITIONAL IPM PROCESS refer to page 34	
2. IDENTIFY PROBLEMS	
	Disorders - refer back to Step 1
	Pest - continue
3. IDENTIFY PEST LIFECYCLES	
4. MONITOR PEST	
5. DETERMINE PEST THRESHOLDS	
6. CONTROL PEST	
	Preventative PHC
	Remediated Site PHC
	Mechanical Control
	Biological Control
	Chemical Control
7. EVALUATE CONTROL ACTIONS	
	Were the control actions effective?
	How did the host react to the control actions?
	Are the control actions sustainable?

PPP Initiatives: Prevention 1st, Remediation 2nd

1. Predispose Plants to Success
    a. Select plants that favour existing soil types
    b. Select plants based on available soil volumes or provide access to larger off site soil volumes
    c. Select trees from hardy northern seed stocks and growers
    d. Pre-plant site assessments guide planting locations
    e. Flexible maintenance periods instead of one standardized period for all species in all soils
    f. Soil cell designs for inner city landscapes
2. Improve Soil Habitat
    a. Reducing soil compaction through:
        i. aeration, cultivation and subsoiling
        ii. zero traffic zones
        iii. establishing Critical Root Zone (CRZ) and Tree Protection Zone (TPZ) guidelines
    b. Increase biological activity in the soil
        a. Seed soil with locally harvested mycorrhizae compatible with the plant family
        b. Reduce synthetic fertilizer use, increase organic amendment use
    c. Increase surface permeability
        iv. removing competing turf grass covers over tree root zones
        v. install organic mulches
3. Public Education
    a. Teach alternative pest control techniques
    b. Encourage ecologically friendly landscape maintenance methods
4. Fight Drought
    a. Reduce drought associated pests and diseases: bark beetles, spider mites, Cytospora, Botryodiplodia and others
    b. Irrigate during prolonged drought
    c. Increase soil surface permeability
        i. Remove turf grass over tree root zones
        ii. Install organic mulches
5. Prevent Wounding
    a. Tree trunk guards reduce string trimmer damage and entry of pathogens
    b. Proper pruning technique and timing
    c. Monitoring and control of disease carrying insects (vectors)
    d. Limit woodpecker damage using wire mesh and decoys
6. Bring Nature Back
    a. Encourage a more sustainable landscape aesthetic
        i. Encourage the public to see landscapes as habitat
        ii. Teach ecological perspectives

iii. Celebrate successes

b. Plant native plants. Native plants get native pests, which are controlled by native predators. Native plants are already adapted to our local climate.

WHAT WE BELIEVE

OUR MISSION

"To promote community quality of life and environmental stewardship through proactive pest management programs."

OUR VISION

"To enhance outdoor enjoyment with pest control solutions which are environmentally and ecologically balanced."

"To educate and cultivate public support for our pest management programs."

OUR GOALS

- To protect our public and greenspace from pests in the most environmentally friendly and fiscally responsible way
- To protect local species diversity from invasive alien species
- To balance the needs of our customers with the needs of the environment
- To use a science based approach to determine this balance
- To educate Grande Prairie residents concerning environmentally friendly pest management solutions
- To promote a new landscape aesthetic based on a combination of non-native and native plants

OUR ACTIONS

- Will be aligned with our Mission and Vision
- Will be aligned with City Council's Vision and Values, Municipal Development Plan, Parks Operations Business Plan and the Environmental Sustainability Plan
- Will use the Plant Protection Process to prevent and treat pest incidence
- Will meet current pest management needs and plan for future needs
- Will embrace environmental stewardship
- Will create public education media and pursue public education opportunities

PARADIGM SHIFT

Construction site

For the purposes of this Management Plan, a paradigm is defined as a worldview that encompasses the set of practices commonly accepted at this time. How our urban green spaces are designed and constructed is the current paradigm. It is becoming apparent that under many circumstances this paradigm is not sustainable from a healthy tree perspective.

Therefore, to transition from traditional practices to a new more sustainable set of practices will require a shift in thinking. This new worldview, though in its infancy, is occurring across North America. Existing practices and standards are being challenged. New more sustainable landscape standards are being adopted.

Example: Several municipalities have established minimum uncompacted soil volume standards for urban trees. This is meant to eliminate the traditional landscape construction methods that create compacted soils resulting in shorter tree lifespans.

This paradigm shift moves the objective from constructing short-term aesthetically pleasing landscapes to constructing long-term sustainable landscapes. The Plant Protection Process is an example of new approaches to landscape maintenance.

To transition from traditional IPM to the proposed Plant Protection Process will require both philosophical and operational changes.

Philosophies

- **Keeping plants healthy will reduce the incidence and severity of pest attacks**
- **Protecting and maintaining soil health is vital**
- **Protecting habitat and species diversity will reduce pesticide use**
- **Incorporating naturalized woodlots and plantings in urban development will increase species diversity and decrease the need for pest control**
- **Embracing ecology in pest control operations**
- **Keeping plants healthy will increase feeding tolerance and usually decrease the incidence and severity of pest attacks.**

The relationship between crop health and attractiveness to pest insects is very complex. Most organisms exude chemical messages to relay many things, including plant health, to any organism evolved to read these messages.

As a result:

- Bark beetles attack weakened trees
- Aphids and leafhoppers are attracted to vigorously growing trees

When site conditions and maintenance are geared to keeping plants healthy then these plants will be better able to tolerate pest feeding. The Plant Protection Process allows us to respond proactively.

TRANSITIONAL STEPS

Discussion, negotiation and consensus

WHERE ARE WE?

The City of Grande Prairie performs pest control activities under an Integrated Pest Management model. This has resulted in pesticide use reductions and an overall reduction in the toxicity of the pesticides used.

WHERE DO WE NEED TO GO?

The Plant Protection Process creates a prevention-first philosophy. Adoption of this philosophy will reduce the need for pesticide use.

If we couple this move with increased public education programs, teaching landowners sound horticultural techniques, we will be able to mirror this move on private lands. Existing survey work has already established that public attitudes are ready to adopt some of these changes.

OUR GOALS

- reduced dependence on pesticides
- pesticide use reductions
- communicate ecological principles to landowners
- healthier environment
- more resilient landscapes
- encourage the use of native plants
- create a new landscape ethic
- increased ecological services
- longer lived trees
- increase species diversity and redundancy
- encourage landowners to think more ecologically

PUBLIC VALUES

Foggy day at Crystal Lake

Values

- What is important to our customers?

- What is in the best interests of our community?

The answer to these two questions defines municipal goals and should be the basis of City Standards.

- It asks both “Can we” and “Should we”.
- It asks what our citizens value about where they live.
- It looks at where we are and where we want to go.
- It is consistent with all nine City Council Principles:
    - Fiscally Sustainable
    - Partnerships
    - Citizen Engagement and Communication
    - City Image / Living the Brand
    - Health, Safety and Wellness
    - Supporting Citizen Potential
    - Customer Centred/Satisfied
    - Adaptable/Flexible/Open to Change
    - Environmentally Responsible

This proposed survey would augment information gathered in the annual Citizen Satisfaction Survey.

Recommendation 1: Survey and Response

1. **Create an in depth Customer Survey that deals specifically with what citizens value at defined locations**
2. **Compare survey results with current service levels and City Standards**
3. **Compile action items, consult stakeholders and build consensus**

Defined locations include:

- Local Street
- Collector Street
- City Centre street
- Neighbourhood park
- Native Woodlots

PUBLIC EDUCATION MEDIA

Materials would include:

- Proper planting and pruning practices
- Designing landscapes which protect plant health and encourage biodiversity
- Educating an ecological perspective
- Encouraging biodiversity in backyards
- Companion Planting and Trap Crops
- Using environmentally friendly alternative pest control methods
- Reducing pesticide use
- Protecting riparian areas

Multi-media campaigns include:

- Invasive Alien Species and how to Identify them
- Risk to native habitats and Agriculture from Invasive Alien Species
- Landowner responsibilities under law

Landowners predispose their landscapes to pest issues through lack of knowledge.

The majority of land inside municipal boundaries is privately owned. If we are to continue to affect positive change, we need ways to help private landowners make informed decisions.

Recommendation 2: Public Education

1. **Create public education materials**
2. **Create multi-media educational campaigns**

ISSUES RELATED TO PUBLIC PERCEPTION

This Plan is largely operational and focused primarily on public lands. However, some areas that affect Grande Prairie residents are:

- Public Relations
  A great deal of information is currently circulated by City Pest Control to aid customers with pest control issues. This information lacks an overall consistent face and format. It is recommended that the City of Grande Prairie:

Recommendation 3: Communication Plan

1. **Create an IPM Communications Plan**
   a. **This will ensure that messages are consistent, follow the goals of this Plan and solicit participation by Grande Prairie citizens.**
2. **Branding City Integrated Pest Management Services**
   a. **The goal is to make the City a premier place to find local pest related information and advice.**

City Pest Management often operates in the background. In order to influence change on private lands the City will need to become a highly visible pest management leader in Grande Prairie. It will need to communicate its messages clearly, using both traditional and contemporary media.

- Pesticide Bylaw
  The results of both the 2007 Pesticide Opinions Survey and the 2012 City of Grande Prairie Pest Management Survey show the public split on the need for pesticide use legislation. City Councils 2008 decision to discontinue the City service of dandelion control rather than implement a bylaw reflects the difficult task of balancing public expectations with the municipality's responsibility for general welfare.
  In essence, this decision resulted in reduced pesticide use on public lands while respecting the landowner's freedom to decide what to use on their own lands.

  This Plan proposes to inspire local landowners to adopt proactive plant health care management techniques that will reduce the need for pesticide application.

ECOLOGICAL PERSPECTIVE

Crystal Lake and adjacent woodlands

WHY BOTHER LOOKING AT ECOLOGY?

Ecology is the branch of biology that deals with the relations of organisms to one another and to their physical surroundings. A goal for our municipality should be to create healthy, sustainable urban ecosystems. Evolution and natural selection are always at work molding ecosystems.

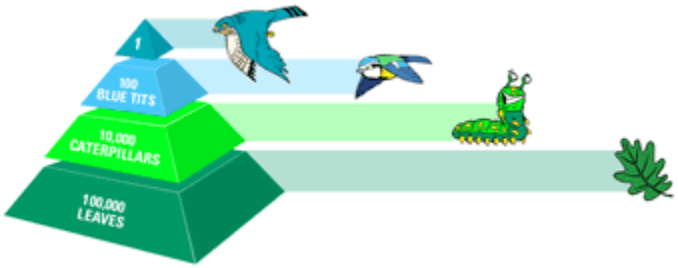
Ecosystems rely on species diversity to ensure that there are always organisms to fit every niche. Moreover, species redundancy occurs so that there are multiple organisms using each niche in case one organism disappears.

Natural systems seldom require manmade pest control solutions, they are self-regulating. Natural systems require large areas, species diversity and large species populations.

If we can incorporate ecological principles into our urban landscapes, we can reduce the need for pesticide applications.

The Food Web

Every organism on earth relies on its ecosystems for food and shelter. This is as true of humanity as it is for simple soil microbes. This simple trophic level pyramid can be used to simplify the complex food web.



Trophic Levels from Terrestrial Plant Producers to the Falcon Carnivore

Trophic levels are about energy and biomass production.

1st Trophic Level are the plant producers, which transform sunlight energy into sugars and carbohydrates.

2nd Trophic Level made up of all the animals that consume these plants. In terms of number of species, this level of primary consumers are dominated by insect herbivores such as caterpillars and grasshoppers.

3rd Trophic Level are the carnivores. These animals feed directly or indirectly on 2nd level primary consumers such as songbirds, snakes or spiders.

4th Trophic Level are the top carnivores that feed on all the lower levels.

Several things become apparent:

- All of the food web is built on the conversion of sunlight to sugar
- The food web is totally dependent on plants to provide food and shelter
- All organisms are reliant on lower levels for their survival
- It requires a large volume of **useable** plant biomass to support a smaller number of insects that are eaten by an even smaller number of carnivores

Plants are the habitat of most insects and many fungi and bacteria. Plants provide food for insect herbivores and everything that eats these herbivores directly or indirectly, going up the food chain. In this way, a hawk is as reliant on the caterpillars that feed the songbirds, as the songbirds themselves.

"So what's the problem? As long as we have lots of plants, the Food Web is intact … right?"

<u>The problem</u> is that not all plants are equally useful to local food webs.

Dr. Doug Tallamy, Professor & Chair of Entomology and Wildlife Ecology at the University of Delaware summed up the problem in 2007:

"… most insect herbivores can only eat the plants with which they share an evolutionary history."

Forest Tent Caterpillar on Trembling Aspen leaf

Why is this?

Many animals, including insect herbivores, evolved to feed on select plants in their environment. In response to (insect) feeding damage, plants eventually developed defensive chemicals called secondary metabolites.

Many of these secondary metabolites are distasteful or even toxic to animals including many insects. Over time natural selection produced insects that could tolerate these defensive chemicals. Eventually plants added new metabolites to better deter insect feeding and again insects responded by adapting. This eventually leads to insects that are only able to feed on plants that utilize certain chemical pathways. These insects are called specialist feeders.

90% of all insect species that compose the 2nd trophic level are specialist feeders. This means that almost all insects rely on native plants for their survival.

Adaptation by natural selection takes a long time to occur because it relies on genetic mutation and natural selection to favour these adaptations over thousands of generations.

Co-evolution is why insect herbivores are reliant on just the plants they evolved over time to feed on.

What do we plant in our urban landscapes?

Only 18.5% of our public trees are species native to our region! Therefore, functionally only 18.5% of public trees make up the 1st trophic Level in our City. Only 18.5% of our public trees can support the native insects that make up the 2nd trophic Level. Private landscapes are typically created using the same landscape philosophy as public landscapes and therefore mirror this ecosystem dysfunction.

No shrub beds inventory exists; however, experience indicates that the percentage of native plants in public shrub beds would be similar. In addition, shrub beds typically do not utilize ground cover plants such as grass and forbs.

Natural environments function because the food webs are composed of the plants and animals that evolved together at that location. It is these complex interrelationships that form the “checks and balances” within the ecosystem. Where you have “checks and balances”, pest management is less likely to be necessary.

At any time, many insect populations will be stable, some will be in decline, and some over populated. A sustainable sized habitat allows fluctuations in population dynamics to occur without species extinction or long-term damage from overpopulation. This buffering effect is due to species diversity and this in turn relies on habitat size.

Where habitat size is limited, so is the ability of the system to bounce back from normal population fluctuations. Grande Prairie encompasses 73 square kilometers. If the municipality were to be planting native species, at a sufficient density, then the resultant landscape would mimic a large native woodlot. Native insect herbivores would expand their habitat into town.

Most insect herbivores are specialist feeder because they have evolved to feed on relatively few different native plant species. Urban forests plants, being largely non-natives, do not feed the living complex of animals that are supported by native plants. This results in:

- A disconnect between native forest ecosystems and urban forest ecosystem
- Less pest control from native animals
- A lack of biodiversity within our urban forest
- Fewer natural controls to pest outbreaks within the urban forest

The insect species that attack our urban forest trees are largely composed of generalist feeders and imported insect species. City pest control needs to control outbreak populations that threaten the health of our trees because native pest control agents are largely absent.

Increasing the biodiversity (native plants and animals) within our urban environment and the adoption of a sustainable landscape aesthetic, will reduce the amount of plant biomass that requires human intervention.

CAUTION:

- Not all native plants are suitable for urban planting. Suitability planting sites for each plant species is crucial.
- Each native selection needs to be trialed before moving to wide scale planting.
- There is currently only a small selection of native plants available in nurseries. Availability to native stock will be a major obstacle.

WHY DOES BIODIVERSITY MATTER?

Biodiversity is the total of all species and ecosystems of a region. Climate and human activities are the two major drivers of change to biodiversity.

Biodiversity matters because ecosystems with few different species are more susceptible to extinction as individual populations fluctuate.

Plants form the base, the lowest trophic level, of all food chains. If we use plants that native insects can eat, we support everything else up the food chain.

Behavioral and biochemical adaptation has led to the development of insect herbivores that are specialist feeders on just a few different plant species. These specialist feeders compose as much as 90% of all local insect herbivores.

Since our built landscapes are largely composed of imported plant species, most indigenous insect species do not feed on these non-native plants. Therefore, we have constructed urban landscapes with reduced species diversity. Landscapes that don`t send captured solar energy up the food chain.

Some people might be tempted to say “the fewer insects in their yard the happier they will be”. However, these insects form the base of the food web that everything else depends on.

The population of most animals within any ecosystem fluctuates with changes in climate and resource availability. Small habitats contain lower numbers of each animal and therefore have an increased risk of local extinctions during population fluctuations. Large habitats can absorb population fluctuations without local extinctions.

An ecosystem built of only a few species of organisms increases the likelihood of pest outbreaks or extinction events. Biodiversity in ecosystems provides a buffer to changing conditions. This can limit the incidence and severity of pest outbreaks.

HOW MUCH DIVERSITY IS GOOD?

Urban landscapes would benefit from more species diversity in plants, animals and microbial communities. More use of native plants will provide habitat for more diverse insect herbivores. These in turn are food for generalist predators such as wasps, spiders, songbirds, rodents and for suitable apex predators such as hunting birds and fox.

AVOID!!!:

- Providing habitat for rodent population adjacent to residential development.
- Encouraging apex predators such as coyote, wild cats, boar or bear to co-habit our City.

Periodic appearance of these animals may occur, but permanent populations should be prevented. As not all animals are suitable in urban centers, municipal operations should also monitor beaver and deer populations within wildlife corridors.

URBAN ISLANDS

Cities are urban islands sitting within natural (woodlands) and/or artificial (agricultural) ecosystems.

Often very little remains of the habitats that existed before human settlement occurred. Native woodlots and riparian areas sometimes exist within urban centres, but these areas are cut off from each other by residential development. Development that does not support native plants and animals forms a barrier between separated native populations. Separated populations are small, subject to periodic population fluctuations, and at risk of local extinctions.

Municipal consideration should be given to the preservation of existing natural habitats. Since humans are hardwired to require green surroundings and natural ecosystems function better than manufactured ones, preservation makes more sense than creation.

Municipalities need to both preserve natural habitats and create new ones. A philosophical change from landscapes of non-native plants to hybrid landscapes of native plants and non-native ornamentals will help re-connect our urban environment to its surroundings.

If we can create native corridors between natural areas then native species populations will be connected, share genetic resources and be less susceptible to population fluctuations.

BRINGING NATURE BACK

Traditionally, riparian areas and native woodlots form a patchwork of native landscapes within an urban centre. Unfortunately, these areas are separated by non-native landscape plantings.

If public landscapes were to use native plant species then a web of plant habitat would connect native woodlots separated by distance. Roadway boulevards and residential developments create opportunities to connect these native areas. When there is habitat for insect herbivores, the predators and parasitoids will follow. As will everything else that requires food and shelter.

Studies show that people need green environments. Green environments result in less crime, better health, wellness, and happier people. Traditionally, municipalities are tasked to provide non-native ornamental landscapes and control regular pest outbreaks. The intent being, to maintain unrealistically perfect landscapes with minimal evidence of feeding damage.

Incorporating native plants (and animals) into these landscapes will create more sustainable green spaces. Native insects will be on these plants. Feeding damage will be apparent. However, this damage is evidence that energy is moving up the food chain and this is a worthy goal.

THE LAND ETHIC

A quote by Aldo Leopold sums up his views on a responsible relationship existing between people and the land they inhabit:

"A thing is right when it tends to preserve the integrity, stability, and beauty of the biotic community. It is wrong when it tends otherwise."

Leopold's book, A Sand County Almanac was instrumental in the development of the early conservation movements. His land ethic is about the interconnectedness of the natural environment and the human necessity of reconnecting with it.

Current landscaping trends rely primarily on non-native plants. These plants do not provide habitat required by the biotic community. While these plants provide valuable environmental services (pg. 118-120), they provide few ecological services (trophic levels).

To provide appropriate municipal services, the City needs to recognize the importance of green environments to our residents and how best to provide these surroundings.

The questions then become:

1. Do we want to continue creating green environments specifically for aesthetics?
2. Alternatively, do we want to create green environments that that support and contribute to local food webs?
3. Do we want to bring nature back into our lives?

The IPM Plan is a vision document. As such, its role is to outline alternative solutions to achieve pest management goals based on current science.

Bringing nature back into our living environment is one solution. Continuing to use non-native landscapes plants, that don't provide food and shelter for native animals, is another.

The IPM Operational Manual, which is in concurrent development, deals with the specifics of pest management operations.

There are <u>no pests</u> in nature

Living things just live their lives. The concept of **<u>pest</u>** is artificial.

Aside from humankind, judgement has no part in nature. In fact, plants protected from all insect attacks produce less chemical repellent compounds. After as little as three generations, they lose some of their inherent ability to repel feeding insects. They transfer resources when there is an immediate need.

Our Urban Forest is not a natural ecosystem

An urban forest is a collection of all the trees, associated shrubs, ground covers and soil ecosystems within the municipal boundaries. An urban forest contains trees on both public and private lands and may contain natural stands, naturalized areas and landscape plantings.

An ecosystem is a dynamic, related complex of living communities and their non-living environment.

An urban ecosystem combines natural and fabricated elements. We recognize that social-economic and built environments exist in the urban ecosystem. This plan focuses primarily on the natural environment component of an urban ecosystem.

Grande Prairie's urban forest, like most prairie urban forests, is an assemblage of largely non-native plants. Therefore, most of the trees lack the web of associated organisms that exist in their native ranges. By design, our urban forest ecosystem lacks connectedness with indigenous organisms.

Public demand for the most attractive plants that will grow here leads to landscapes designed for aesthetics rather than sustainability.

In general, urban forest ecosystems lack the rich pallet of predators, parasitoids and microbes found in the native ecosystems where these plants evolved. This lack of natural predators coupled with the overuse of a few tree species means that pest outbreaks occur more often and may last longer. Urban forest trees often lack the inherited feeding tolerance that develops when plants and animals evolve together over thousands of years.

As we continue to use non-native plant species in our landscapes, we continue to acquire additional pest management responsibilities.

Ecological balance is not static

A commonly held belief is that when a pest outbreak occurs that something in the ecosystem must be broken or out of balance. In the case of urban landscapes, the ecosystem is dysfunctional.

Individual systems are in a state of constant change. The appearance of balance depends on what level the observer is focused. When viewed from a distance the observer sees balance but when looked at closer they see that constant change is the norm.

For example a residential Maple Tree:

A warm rainy spring results in lush new growth on a Manitoba maple tree. An abundance of soft, nitrogen rich food means that aphid populations grow exponentially. Several weeks later, an abundance of aphids (primary herbivores) provide food for a growing population of ladybird beetles (predators). The next season an abundance of predators, mean that the abundance of aphids is down and excess ladybird beetles fly off in search of prey.

From a distance, all the owner sees are minor changes to the tree's appearance. Up close, all the components of the food web interact, create feedback loops, are reliant upon resource abundance and react to climatic conditions. There is a constant ebb and flow.

PEST MANAGEMENT PERSPECTIVE

Agricultural crop production

What is at Risk?

- There are over 7 billion people on the planet.
- There are about 320,000 (named) vascular plants.
- Humanity relies on a handful of plants to feed almost all of these people.
- In the world today, 103 plant species make up 90% of the world's food supply. Of these species just 10 plants: corn, wheat, rice, potatoes, cassava, soybeans, sweet potatoes, sorghum, yams and plantains dominate most of humanity's diet.
- With worldwide reliance on a relatively small number of crop plants, any organism that is damaging to agricultural production **will get pest status**.

Pest management is (usually) initiated when the cost of control is less than the revenues lost to crop value. Using current agricultural practices, pest management is not a luxury but a

necessity. The IPM process provides a framework to decide when pest management is warranted and how to minimize ecological impacts.

CONCEPTS

What is a Pest?

A pest is an organism with traits that people see as damaging or unwanted. The key component of this definition is that humanity dictates what we label as pests.

Integrated Pest Management

IPM is a decision based pest management system. It is used to assess suitable techniques to reduce pest populations to tolerable levels while protecting environmental sustainability.

Table 3. Typical IPM Process

INTEGRATED PEST MANGEMENT PROCESS		
1. IDENTIFICATION		Identifies the pest and /or all the contributing factors
2. LIFECYCLES		Researches the life cycles of both the pest and host
3. MONITOR		Monitors pest populations
4. THRESHOLDS		Establishes action thresholds
5. CONTROL TYPES		Decides if management is necessary and if so what combination of control options are needed
	Cultural	Eliminates the conditions favourable to pests. Tactics include improving and amending the soil; choosing hardy plants and good water management
	Mechanical	Eliminates pests by physically removing them. Examples are hand picking, rinsing with water or using a spring mousetrap
	Biological	Uses one organism to eliminate another (pest) organism. Examples are applying Lady Bird Beetles to aphid infested plants
	Chemical	Applies elemental, chemical or bio-rational based pesticides
6. EVALUATE		Observes both the degree of pest management achieved and any host reactions

Mosquito control helicopter landing

Why we moved to an IPM approach:

Example: IPM vs. Pest Control

Mosquitoes bother people and sometimes carry diseases. We recognize that mosquitoes are an important food source for aquatic and terrestrial animals. Not all mosquito species bother humans. However, not controlling the nuisance species mosquitoes is often not an option.

Pest Control Approach:

- Recognise that mosquito populations are bothering people.
- Identify the mosquito habitats.
- Identify the easiest and cheapest method to control the mosquitoes.

- Control the mosquitoes (either adult control by fogging land or aquatic control using effective low cost larvacides).

IPM Approach:

- Identify the nuisance mosquito species (keying adults and larvae to species)
- Identify which species are a nuisance to people and/or livestock
- Identify their habitats and lifecycles
- Monitor nuisance mosquito populations (larvae in water and adults on land)
- Compare growing mosquito populations against thresholds to decide if control is warranted
- Determine the methods of control warranted which will minimize ecological impacts:
    - Mechanical (filling in a low area in a farmer's field is feasible. Filling in a wetland is ecologically a poor solution)
    - Chemical (controlling mosquitoes in the larval life stage, using a pesticide designed to target only aquatic flies and at rates that only kill mosquito larvae, is the ecologically sound solution.) Fogging the bush kills many non-target insect species and is **not** necessary in Grande Prairie.
    - Biological (Apply *Bacillus thuringiensis* var. i*sraelensis* to temporary standing water at label rates)
- Evaluate and document the success of actions taken.

Historical Pest Control

West Nile Virus mosquito control operation. NBC News, California, 2012

Pest management techniques developed because of the move to domesticate plants and animals over the last 10,000 years. Living in one location, raising herds of animals and field crops leads to large seasonal pest populations. Mono cropping (mass planting a single plant species) imposes a 'shallow' ecosystem at the expense of displaced plants and animals, which would normally exert some control on pest populations.

Pest control using sulphur and other natural elements dates back over 4000 years. More recently botanical extracts, soaps, oils and synthetic chemical products have been adopted.

Present Day Pest Management

IPM is the standard used for pest management in the developed world. The Plant Health Care (PHC) process developed by the International Society of Arboriculture is gaining acceptance. This is a practical approach to reducing pest attack severity by increasing plant health. This approach requires changes to the large-scale construction methods used today.

Lindgren Funnel Trap with Alpha-pinene lures to attract beetles

Future Pest Management

Tree canopy trained high to increase light exposure

Biological and bio-rational pest management solutions will dominate the industry. Increasing restrictions on both product registrations and legislation will guide what products are used in an urban setting.

There will be a move towards creating more sustainable cities in Canada. This will drive changes to existing design and construction standards. Engineers and planners will accept landscape plantings as Green Infrastructure.

Less is More Philosophy

An IPM professional understands:

- That there are existing ecological systems in place
- That these systems combine native and non-native plants, animals and microorganisms
- That taking action will have consequences on one or more components of these systems
- That these consequences may not be easily seen or identified
- That wherever possible habitat damage and pesticide applications should be avoided
- That where necessary pest control measures should be performed to protect people and habitats from invasive and dangerous pests

What is a Pesticide?

"Any product, device, organism, substance or thing that is manufactured, represented, sold or used as a means for directly or indirectly controlling, preventing, destroying, mitigating, attracting or repelling any pest". (Health Canada)

Pesticide is a blanket term covering all types of pest control products:

- Insecticides (products used to control insects)
- Herbicides (products used to control plants)
- Acaricides (products used to control mites and spiders)
- Avicides (product used to control birds)
- Rodenticides (products used to control rodents)
- Algaecides (products used to control algae)
- Bactericides (products used to control bacteria)
- Virucides (products used to control viruses)

What constitutes a pesticide in Canada is:

- A product with the ability to affect a pest (efficacy)
- A product advertised as a pest control product

- A product registered with the Pest Management Regulatory Agency of Health Canada

A pesticide can be chemically or biologically derived.

The Poison is in the Dose!

Philippus Aureolus Theophrastus Bombastus von Hohenheim 1493-1541 (the German-Swiss alchemist often called Paracelsus) said," All things are poison, and nothing is without poison; only the dose permits something not to be poisonous."

A valuable concept to understand is that "the dose makes the poison". It brings the perception of pesticide toxicity in line with objective measurements.

Monument to Paracelsus in Bavaria

Every living thing relies on chemistry. Plants use sunlight to fuel the biochemical process called photosynthesis. People use the sun to create vitamin D3. The water we drink is a solvent used to carry nutrients inside our bodies and remove toxins from our bodies.

Organisms are biological entities that chemically interact with things they consume and/or touch in their environments. Whether these interactions are positive, negative or neutral depends upon the degree and nature of exposure. The poison is in the dose.

When a compound is added to the environment, such as a pesticide, there will be resulting effects. The goal of IPM is to minimize these effects through sound judgement.

LD50

The Canadian Centre for Occupational Health and Safety defines LD50 as *"the amount of a material, given all at once, which causes the death of 50% (one half) of a group of test animals. The LD50 is one way to measure the short-term poisoning potential (acute toxicity) of a material."*

LD50 values in mg/kg (milligram/kilogram) of body weight express relative toxicity of only the active ingredient. If a pesticide needs to be used then the IPM process will seek to select a control product, with the lowest toxicity as demonstrated by its LD50 (the higher the LD50 number, the lower the toxicity). Product selections must be both affordable and effective.

Toxicity

Toxicity is the degree to which a substance can damage an organism.

"A central concept of toxicology is that effects are dose-dependent; even water can lead to water intoxication when taken in too many doses, whereas for even a very toxic substance such as snake venom there is a dose below which there is no detectable toxic effect."

Acute Toxicity

"The adverse effects of a substance that result either from a single exposure or from multiple exposures in a short space of time (usually less than 24 hours). To be described as acute toxicity, the adverse effects should occur within 14 days of the administration of the substance. (Wikipedia)

The following table is a composite of many published tables. It lists many substances and their corresponding oral LD50 **acute toxicity** values. Dermal LD50 values (not shown here), are usually lower and therefore far less toxic than oral LD50 values for the same chemical. While most people would never encounter many of these substances, they are listed here alongside common compounds for comparisons.

Table 4. Relative Toxicity Comparisons (mg of a substance per kg of body weight that results in the death of 50% of the test population)

Substance	**LD50 Values**
Botulinum toxin (Botox)	0.000001 mg/kg (estimated)
Dart frog poison	0.002 mg/kg (estimated)
Puffer fish	0.008 mg/kg
Dioxin	0.02 mg/kg
Fat tail scorpion	0.32 mg/kg (variable)
Black mold toxins	0.5 mg/kg (variable)
Black widow spider	0.9 mg/kg
Prairie rattle snake	2.25 mg/kg
Wasp sting	2.5 mg/kg (purified)
Common bee sting	6.0 mg/kg
Sodium cyanide	6.4 mg/kg
Strychnine (rat poison)	16 mg/kg
Nicotine	50 mg/kg
DDT insecticide	113 mg/kg
Caffeine	192 mg/kg
Aspirin	200 mg/kg
2,4-D Amine (herbicide)	300 -1000 mg/kg (variable)
Malathion (insecticide)	480-10000 mg/kg (depending upon purity)
Liquid hand soap	1260-5000 mg/kg (variable)
Acephate insecticide	1494 mg/kg
Table salt	3000 mg/kg
Baking soda	4240 mg/kg
Glyphosate (herbicide)	5600 mg/kg
Ethanol (drinking alcohol)	7060 mg/kg
Vitamin C	11,900 mg/kg
Table sugar	29,700 mg/kg

It is Important to Know:

- LD50 is useful for comparing active ingredients for relative acute toxicity
- LD50 does not indicate the acute toxicity of a pesticide as adjuvant testing for LD50 are not disclosed and considered proprietary information
- LD50 does not tell anything about chronic toxicity.
- LD50 values will differ between different test animal species and between individuals within each species.
- LD50 values are starting points and need to be taken in context with many other factors to determine relative risk. The Pest Management Regulatory Agency (PMRA) of Health Canada considers these factors when allowing the registry of all pesticides in Canada.

The degree of toxicity to test animals does not guarantee a close correlation to humans. Comparative toxicity as cited using reported LD50's is a crucial tool used by IPM practitioners when selecting effective but less toxic pesticides.

Chronic Toxicity

*"A property of a substance that has toxic effects on a living organism, when that organism is exposed to the substance continuously or repeatedly." (*Wikipedia)

Asbestos poisoning is an example of chronic toxicity.

Plant Health Care (PHC)

PHC is a proactive management process that emphasizes maintaining plant health to reduce the occurrence of pests, disease and disorders. Therefore, the plant and its requirements become the central focus of activities. It then becomes crucial to understand both the plant's requirements and how to monitor site conditions. Steps in a typical PHC process:

Table 5. Plant Health Care Process

PLANT HEALTH CARE PROCESS		
IDENTIFICATION		Identify the plant species present and what resources they need: air, water, nutrient and soil
PIC CYCLE		Identify site conditions
	1. Predisposing Factors	Factors that reduce the hosts tolerance to stress
	2. Inciting Factors	Primary stressors
	3. Contributing Factors	Secondary stressors
REMEDIATE	New Landscapes	Select plants suitable to site conditions
	Existing Landscape	Remove or replace plants unsuitable to the site conditions (reduces incident of pests and diseases) Improve site conditions, where possible, to match the plant's needs (not easy if the plants present have very different needs)
MONITOR	Pests & Disorders	Use the IPM Process

HARMONIZING PEST MANAGEMENT WITH ECOLOGY IN GRANDE PRAIRIE

City of Grande Prairie Pest Management Goals

- Maintain local ecology
- Protect species diversity in riparian areas from Invasive Alien Species
- Encourage the use of native plant species in landscapes to rebuild a natural ecosystem
- Manage provincially and federally mandated pests using an IPM decision making process
- Reduce the incidence and severity of pest outbreaks by using a Plant Health Care principle
- Work to educate the public regarding ecologically friendly pest management
- Work to change landscape aesthetics to a more sustainable ecological model

MOSQUITO SURVEILLANCE AND CONTROL

Mosquito larvae monitoring cup

There are 12 mosquito species in the Grande Prairie area. Some of these are host specific to animals and some are opportunistic, feeding on people, birds or grazing animals.

- Program runs from March – August
- Program targets nuisance species mosquitoes
- 235 hectares of annually treated standing water
- The biological larvacide *Bacillus thuringiensis* subspecies *israelensis* is used to control mosquito larvae. This product is target specific to biting flies and is largely inert to all other life forms
- Rural road ditches, low areas in pasture and fields from April – August
- The Aerial Program runs for one day, in late April or early May, targeting 2nd to 3rd larvae development stage
- Surveillance and spot treatments by ground application, as needed, June-August

This program must stay current with developing provincial guidelines, such as the new Alberta Wetlands Policy. It is possible that as these new guidelines develop it will spur changes to current regulations regarding pesticide applications near Open Bodies of Water.

City IPM maintains a 3-5 kilometer buffer outside municipal boundaries where most of the mosquito control activities occur. As municipal boundaries expand, more area needs to be

surveyed to find the new mosquito habitat sites. The mosquito control boundaries are then expanded to maintain the buffer.

Both larval and adult mosquito monitoring are performed to identify where these insects are developing and to guide control decisions. Monitoring has been used to determine relative risk to our customers regarding West Nile Virus. Previous work determined that the risk to our residents from this disease is very low.

If *Culex tarsalis,* which is the primary mosquito species that carries West Nile Virus, is detected in Grande Prairie, City IPM will respond with increased trap monitoring and begin virus screening. To date this mosquito species does not occur here.

WEED CONTROL

Cosmetic Weed Control

Cosmetic Weed Control use herbicides simply to maintain a tidy appearance rather than to protect the health of a crop. In 2008, City Council voted to discontinue the City service of broadleaf weed control (dandelion control). An exception was made to enable the City to control these weeds on specific high intensity sports fields and select highly ornamental parks.

The City's Dandelion Control Program accounted for the second highest volume of pesticides applied each year, second only to mosquito control. This decision, to scale-back this service, resulted in an annual use reduction of 1200 litres of herbicides. Unlike mosquito control, no bio-pesticides were available that were both effective and affordable. The City tests new bio-herbicides, for efficacy, as they reach the market. To date, no product has been effective and affordable.

The City performs non-selective (Roundup) weed control on downtown sidewalks, concrete medians and many pathways around the city. No weed control is performed on residential sidewalk sections.

Regulated Weed Control

Under the Weed Control Act of Alberta and Regulations, landowners are required to:

- Destroy all prohibited noxious weed species
- Control all noxious weed species

Destroy means to destroy the entire plant and render all parts, including the seeds, unproductive.

Control means that actions must be taken to stop the spread of these common weeds. Therefore, control should prevent the production of seeds and, in the case of creeping root systems, prevent their spread using herbicides.

The City has a legal obligation to appoint weed inspectors to both inspect and force compliance with the Act and Regulations. In addition, the City as landowner is responsible for weed control on public lands as dictated by the regulations. For more information, see pages 51-59 Invasive Alien Species.

TREE PESTS

Forest tent caterpillar defoliated aspens near Dunvegan 2012

Annual Monitoring Programs run to protect our Urban Forest trees:

1. Forest Tent Caterpillars	Late May early June, July for adult moths
2. Invasive Forest Pests	May-September
3. Native and European Elm Bark Beetles	May-September
4. Spotted-Wing Drosophila	May-September
5. Aphids on Maple and Cherry Trees	June
6. Yellow Headed Spruce Sawfly	Mid-June
7. Ash Plant Bugs	Mid-June
8. Pear Slug Sawfly	Mid-July
9. Western Ash Bark Beetle	June-July
10. Mountain Pine Beetle	July-September
11. Indoor Plantscapes	All year

INCIDENTAL PESTS

Spruce spider mites

Spruce spider mite damage

Random pest outbreaks occur that sometimes require management to protect the health and aesthetics of stressed host plants.

1. Agromyzid Elm Leafminer	May
2. Birch Leafminer	June
3. Ants and nuisance wasps	June-August
4. Two Spot spider Mites	July
5. Spruce Spider Mites	May-July
6. Birch Leaf Skeletonizer	August

AESTHETIC PEST ISSUES

Often insects will create aesthetically unpleasant side effects on host plants during their life cycle such as minor shot holes or rolled leaves. This minor damage does not affect the plants health but is of great concern to homeowners. As a rule, the IPM process would not consider this damage as requiring pest management except where the plant has exceptional ornamental value or historical significance.

1. Ash Leaf-cone Rollers
2. Ash Mid-rib Gall Midge
3. Eriphyid Mites of Hardwoods
4. Cooley Spruce Adelgids
5. Willow Red-gall Sawfly

PLANT DISEASES (PATHOGENS)

Viruses, fungi, bacteria or mycoplasmas cause plant Disease. They can be the primary or secondary pathogens. Primary disease agents invade a host plant causing a plant disease. Secondary pathogens invade a host plant after some other plant stress has occurred such as drought, insects or a primary pathogen infection. The City currently run monitoring programs for:

Bronze Leaf Disease, Dutch Elm Disease, Black Knot and Fire Blight.

VERTEBRATE MANAGEMENT

Table 6. Summary of Pest Control Jurisdictions

Organization Responsible	**Telephone Contact**	**Animal of Concern**	**Pest Control Legislation**
Alberta Fish & Wildlife	780-538-5265	Deer, moose, coyotes, cougars	Wildlife Act of Alberta
Enforcement Services	780-830-5790	Rats, pigeons, muskrats, skunks, racoons, exotic animals (imported snakes etc.)	Agricultural Pests Act
Enforcement Services	780-830-5790	Dogs, cats	Animal Control Bylaw
Enforcement Services	780-830-5790	Residents feeding wildlife	Noise and Nuisance Bylaw
Parks Operations - IPM	780-830-5018	Insect pests, noxious weeds and plant diseases on public lands	Weed Control Act, Plant Protection Act, Agricultural Pests Act and City Service Levels
Parks Operations - Muskoseepi	780-538-0451	Beaver and Muskrat in Muskoseepi and Crystal Lake Parks **Only**	Not protected species
Transportation	780-538-0354	Beaver and Muskrat in storm ponds	Not protected species
Facility Maintenance	780-538-0484	Insects and rodents in Civic buildings/ performed under contract	Environmental Protection and Enhancement Act, Alberta Code of Practice for Pesticides
RCMP and Enforcement Services	780-830-5790	Stray Livestock (cows, bison and horses)	Stray Animals Act
Discretion of Landowner	NA	Magpies, Crows, Ravens, English sparrow	Not protected, trapping only
Control **not** permitted in the City. Hunting Permit required.	NA	Geese, ducks	Migratory Birds Convention Act, Wildlife Act of Alberta

CURRENT MONITORING AND SURVEILLANCE PARTNER PROGRAMS

IPM runs trapping programs for a number of partner agencies:

1. Spotted Wing Drosophila for **Alberta Agriculture and Rural Development**
2. Brown Marmorated Stink Bug for **Alberta Agriculture and Rural Development**
3. Invasive Forest Insects for **STOPDED and CFIA**
4. Emerald Ash Borer for **CFIA**
5. Dutch Elm Disease Vector Trapping for **STOPDED**
6. Noxious Weed Control partnered with the **County of Grande Prairie No.1**

INVASIVE PEST STRATEGIES

Norway rat

Wood wasp

Sudden oak death disease

Tansy infestation

The City of Grande Prairie is one of many organizations that actively fight to manage alien invasive species. Municipalities, provincial and federal ministries and private organizations form a coalition in a coordinated approach targeting these aggressive species. The goal is either to eradicate, manage their spread or reduce the impact these organisms have on native ecosystems. Priorities are determined by government legislation.

What is an invasive alien species?

Invasive alien species are species whose introduction and spread outside their natural past or present distribution threatens biological diversity. Biological diversity is one of the pillars which sustain ecosystems.

Alien invasive species are species that are new to an area. They may be introductions from other countries or other provinces.

Our local ecosystems are at risk from invasive alien organisms such as noxious weeds, insects and microorganisms. These invasive pests often have competitive advantages over other organisms because:

- Hereditary traits such high germination rates, massive seed production, aggressive rooting strategies, allelopathic root exudates, adaptation to diverse soils, or as generalist feeders
- Lack of local herbivores and predators that controlled them in their native habitats

Why are invasive alien species a problem?

- Invasive alien species threaten riparian areas through species displacement. They can increase slope erosion and water degradation.
- For example, Purple Loosestrife was imported from Europe as a garden plant. Its seeds escaped and purple loosestrife now dominates many riparian habitats. It forms dense mono crop stands displacing most of the local plant. It displaces the native habitats required by insects, ducks and muskrats.
- Our local ecosystem is finite in size and capacity. If invasive alien species force out local species then the ecosystem will lose diversity. The interconnected nature of an ecosystem will be impacted. Food sources for some organisms will be limited while others will flourish.
- Invasive species affect the agricultural industry directly by reducing crop yields and profits
- A loss of biodiversity from invasive alien species impacts agricultural crops indirectly

    For example, Colony Collapse Disorder (CCD) is the mysterious collapse of honeybee colonies. CCD has the potential to limit crop pollination and reduce yields.

    If honeybee colonies were to collapse globally, western crop production would also collapse. Alternative pollinators depend on the diverse habitats threatened by invasive alien species.

Why bother managing invasive alien species?

- Legislation:

    Landowners are often required to control these by law under federal and provincial legislation.

- Statistics:
    - 27% of all vascular plants in Canada are invasive alien species
    - 80% of agricultural weeds species (2002) are invasive alien species
    - 24% of Species at Risk (SARA) in Canada result from invasive alien species invasions

- Associated Costs:

Invasive alien species pose environmental, economic, social and human health costs to Canadians and our ecosystems.

Estimated costs associated with just 16 of these invasive species are between $13.3 and $34.5 billion annually. (*Characterized and Projected Costs of Nonindigenous Species in Canada 2003)*

Causes:

- loss of habitat
- reduced crop yields
- loss of export markets
- land devaluations
- direct management costs
- indirect environmental costs
- inspection, monitoring and quarantines costs

Regulatory Framework

The Convention on Biological Diversity 1992 (CBD)

180 countries agreed to prepare national biodiversity programs

Canadian Biodiversity Strategy Canada's Response to the Convention on Biological Diversity 1995

Canada met its convention obligations

The Strategic Plan for biodiversity 2011 – 2020 and the Aichi Targets

Detailed specific targets and target dates.

This is important because habitat loss from invasive alien species is one of the major threats to global biodiversity today.

Management of invasive alien species in Canada requires a cooperative effort between federal, provincial and local authorities. To validate the efforts several pieces of legislation have been created which form the authority to act, the framework of decisions and allocates the responsibility to act.

In Canada

Canadian Food Inspection Agency (CFIA) administers a number of Acts, and Regulations designed to:

- Safeguard our food supply
- Protect the health of animals and plants
- Enhance the well-being of Canada's people, environment and economy.

CFIA's plant protection authority comes from the *Plant Protection Act*.

- **Plant Protection Act of Canada** S.C. 1990, c.22

  "To protect plant life and the agricultural and forestry sectors of the Canadian economy by preventing the importation, exportation and spread of pests and by controlling or eradicating pests in Canada."

- **Plant Protection Regulations** 29 (2a)

  Lists federally regulated pests in Canada.

Environment Canada administers strategies to analyse entry pathways, detect entry and manage entrance of alien invasive species into Canada.

- **An Invasive Alien Species Strategy for Canada**

An overall strategy proposed to respond to the invasive alien species challenge through a hierarchical approach. This approach prioritizes prevention, early detection, rapid response and management to contain, eradicate and control.

Parks Canada administers Acts and Regulations designed to protect Canada's National Park system from invasive pests.

- **Species at Risk Act** (SARA) S.C. 2002, c 29

  Three main goals:

- To prevent endangered or threatened species from becoming extinct or extirpated (gone from one location but still surviving somewhere else).
- To help in the recovery of endangered, threatened and extirpated species.
- To manage species of special concern to help prevent them from becoming endangered or threatened.

In Alberta

Alberta Agriculture & Rural Development administers a number of Acts and Regulations intended to monitor and detect invasive pests in Agriculture and Riparian areas.

- **Weed Control Act of Alberta, Statutes of Alberta, 2008** Chapter W-5.1

  Provincial legislation to prevent the establishment of Prohibited Noxious weed species and control the spread of Noxious weed species through the regulation, inspection and compliance of the Act.

- **Alberta Regulation** 19/2010

  Lists provincially regulated weeds in Alberta into two categories based on their prevalence in the province:

  Prohibited Noxious class weeds must be 'destroyed'
  Noxious class weeds must be 'controlled'

- **Agricultural Pests Act of Alberta, Revised Statutes of Alberta 2000** Chapter A-8

  Legislation in place to ensure the safety of Alberta's food chain as well as the protection of property and humans from declared pests and nuisances in the Province of Alberta.

- **Pest and Nuisance Control, Alberta Regulation** 184/2001

  A regulation in place to manage, control and eradicate pest and nuisance species in Alberta. Pests must be 'eradicated' and nuisances may be 'controlled'.

Joint Federal and Provincial Programs

- **CFIA, Natural Resources Canada, Alberta Agriculture & Food and Alberta Sustainable Resource Development**

  Alberta Critical Plant Pest Infestation Response Plan, Schedule "A'

  An action plan that is "intended to provide the lead agencies with the support required to ensure co-ordinated, efficient and effective management of a critical plant pest infestation in Alberta on either private, provincial or federal lands."

In Grande Prairie

Local Authority may appoint inspectors under existing bylaws, provincial or federal legislation to inspect and enforce the control or destruction of legislated pests.

The level of authority granted is dependent on the terms of reference of the enacted legislation. In general, where overlapping jurisdiction occurs the overseeing authority will be the higher level of government.

HOW THESE ORGANIZATIONS COME TOGETHER.

Table 7. City Response to Invasive Pest Incidence

Invasive Pest Incidence	Authority	City's Response
Prohibited Noxious Weed	Weed Control Act of Alberta	Follow the Weed Control Act of Alberta regulations, IPM process and eliminate prohibited noxious weed species.
Noxious Weed	Weed Control Act of Alberta	Follow the Weed Control Act of Alberta regulations, IPM process and control the spread of noxious weed species.
Invasive Alien Species Plant and Animal Health	Canadian Food Inspection Agency (CFIA) Regulated Pest	1. Immediately contact CFIA. 2. Collect samples to verify identity. 3. Receive direction from CFIA regarding management decisions. 4. CFIA may implement quarantines.
Pest & Nuisance Species	Agricultural Pests Act Regulated Pest	1. City Nuisance Pest Inspector obtains sample 2. Verify identification. 3. Issue a Pest Infestation Tag and control the movement of the pest.
Invasive Alien Species	Critical Pest Invasion in Agriculture or Forestry (as defined in the Alberta Critical Plant Pest Response Plan)	1. Contact Alberta Agriculture and Rural Development. The Critical Pest management Council will determine if this pest requires the activation of the Alberta Critical Plant Pest Response Plan. If so, they will assign a lead department and assign responsibilities to all jurisdictions. 2. Collect samples to verify identity. 3. Receive direction from lead department.

Weed Inspector picking the noxious weed Leafy Spurge

Other Relevant Legislation

Alberta Wildlife Act. 2000, Chapter W-10
Ensures the conservation of wildlife and the habitats they rely on.
Alberta Wildlife Act Regulations, 143/97
Outlines the type, limits and restrictions of the control of wildlife, the protection of endangered species and the hunting of game animals.
Migratory Birds Convention Act, 1994, S.C. 1994, c 22
Ensures the conservation of migratory bird populations by regulating potentially harmful human activities. Control of nuisance game birds such as geese on golf courses must follow this legislation.
Migratory Bird Regulations C.R.C., c. 1035
Outlines the type, limits and restrictions of the hunting and use of migratory birds in Canada. Limits the accidental killing of a migratory game bird species requiring protection.
Pest Control Products Act, S.C. 2002, c 28
Protects human health, safety and the environment by regulating what control products are available to the pest control applicators.
Pest Control Products Regulations SOR/2006-124
Ensures the acceptability of the risks, merit, and value of pest control products used in Canada. Focuses on the protection of human health and the environment as well as product performance.
Environmental Protection and Enhancement Act of Alberta (EPEA), Revised Statutes of Alberta 2000 Chapter E-12
Supports and promotes the protection, enhancement and wise use of the environment. It attempts to bridge the clashing human social and economic needs with ecosystem health and sustainability.
Pesticide Sales, Handling, Use and Application 24/97
Governs the sale, handling and application of all pest control products.
Pesticide Ministerial Regulation 43/1997
Under Alberta legislation, the federal classes of pesticides (identified on the Pesticide Product label) have been further subdivided into four categories or schedules based on a pesticide's potential hazard to human health or the environment and its label use patterns.
Environmental Code of Practice for Pesticides 2010
Provides specific details regarding the safe sales, handling, use and application of pesticides to ensure environmental protection.
City of Grande Prairie, Health and Safety Policy No. 403
http://www.cityofgp.com/index.aspx?recordid=142&page=786
Outlining employer and employee responsibilities for safety.

FISCAL IMPLICATIONS

The Integrated Pest Management work area is comprised of three work units:

Technical Unit
Pesticide Application Unit
Weed Inspection Unit

An assessment of fiscal implications related to the implementation of this Plan must first look at current needs. Labour resources were compared to existing workloads to determine sustainability and secondly, to proposed Plan projects to determine expected workloads.

Assessed Criterion:

- Are we currently doing work we could drop?
- Do existing resources meet existing workloads?
- Can resources be reallocated to fill gaps?
- Will initiatives under the Plan require additional resources?
- Will annexation of lands during the 10-year relevance period of this plan require additional resources?
- Are there requirements for formal education and specialized training?

It was determined:

- That some existing programs are currently under-resourced.
- That some valuable programs have been dropped to free up resources for priority work.
- That implementing the Plan research cannot be undertaken with existing resources.
- That work related to private pest problems are opportunities to communicate our program goals and serve our customers.
- That the technical unit requires:
    - technically inclined individuals with formal education in horticulture, entomology, agriculture or forestry
    - lab and field work experience
- That running technical programs with seasonal workers is impractical.
- That pesticide applicators and authorized assistants undergo extensive training and provincial testing. It is against provincial regulations to use temporary labourers without first providing extensive training.

Results:

Work Unit	Nature of Shortfall	# of Person Hours
Technical	Existing	694
Technical	Proposed under Plan	867
TOTAL		**1561**
694 hours equates to one summer seasonal position. 1561 hours equate to 75% of one full time position needed to meet both existing and proposed projects. This calculation does not take into account any expansion of municipal boundaries from annexation.		

Work Unit	Nature of Shortfall	# of Person Hours
Pesticide Application	Existing	1032
TOTAL		**1032**
1032 hours equates to 1.74 summer seasonal positions. Since pest management activities often require a minimum of 2 persons/crew, it is advisable to hire two seasonal workers.		

Work Unit	Nature of Shortfall	# of Person Hours
Weed Inspection	Existing	520
TOTAL		**520**
The Weed Inspectors currently inspect only 80% of all parcels in Grande Prairie. 520 hours equates to one summer seasonal position working from June until August.		

Staff additions in the 2015-2018 budget process will ensure pest management programs catch up and keep pace with existing work.

Recommendation 4: Staff Implications

1. **To meet existing and future regulatory obligations will require two additional seasonal <u>Pesticide applicators</u>**
2. **To meet existing and future integrated pest management needs will require one additional <u>Insect Technician</u>**
3. **To meet additional Weed Inspection needs will require one additional seasonal <u>Weed Inspector</u>**
4. **These positions should be included in the 2015-2018 Operational Budget**

Possible Annexation:

It is not possible to calculate at this time how the proposed annexation will affect services or determine resource shortfalls. It is safe to say that the City will accept additional work during the 2015-2018 budget cycle.

Proposed under the Plan:

Transitioning from standard Integrated Pest Management to the new Plant Protection Process model (IPM + PHC) will require a commitment to both continue current pest management programs and include additional technical analysis in these areas:

- Soil analysis
    - Bulk density testing
    - Grain size distribution testing
    - Soil chemistry
- Tree demographic data analysis
    - Street tree demographic modelling software
    - GPS data collection and GIS integration
    - Utilize Riparian Health Assessment data to target invasive alien species
    - Planting site assessments and site remediation
- Pest and disease identification/diagnosis
    - Additional monitoring programs
    - Provide our customers with horticultural advice:
        - to increase plant health
        - reduce pesticide use

    - Provide our customers with pest and disease identification and control advice
    - A homeowner version of the IPM Operational Manual will be put online
- Public education programs
    - These programs are extensions of existing City pest programs on private lands
    - New programs focusing on horticulture design and maintenance to replace pesticide use
    - Coordinated approach with City Environmental Sustainability
    - Unifying City IPM messaging and communications
    - Expanding pest management webpages to include sustainable landscape information

Fleet and Equipment:

- No truck purchases will be required during the 2015-2018 budget cycle. An existing tree-insect sprayer should be repurposed to equip an existing lease truck for herbicide use.
- A truck mounted granular blower should be sourced, for more cost effective mosquito control in roadside ditches.
- Two mosquito backpack blowers, normally replaced at amortization, should be retained and used to increase work capacity.

Pesticides:

City IPM has replaced most of its traditional synthetic insecticides with biological and least toxic alternatives. 99% of the insecticides applied are biological control products.

However, weed control operations still rely upon traditional herbicides as few bio-herbicides have been commercialized. Control of regulated noxious weeds is mandatory and until environmentally friendly herbicides reach the market, the City must continue to use traditional herbicides, in an IPM vegetation management program, to control these plants.

- New bio-herbicides, though usually very expensive, should be trialed to determine efficacy, cost efficiency and suitability for municipal operations. One upcoming product utilizes the fungi *Phoma macrostoma* to control broadleaf plants. If this trial were successful, City IPM would have an environmentally friendly product to use on noxious weeds. Once the product is for sale, testing and implementation would likely be ready for the 2019 budget cycle.

TREE PROTECTION

Weed trimmer damage

- How Much Soil?
- The Right Tree for the Right Site
- Why Protect the Urban Forest?
- Summary of Urban Forest Benefits
- Why Should Pest Management be concerned with Urban Forestry?
- Root and Crown Protection

How Much Soil?

A tree's requirement for soil can be expressed in two ways:

- By tree canopy area: 1.3 ft^3 of accessible soil for every 1ft^2 of tree canopy.
- By trunk diameter: 60 ft^3 of accessible soil per inch trunk diameter measured at 1.4 meters above grade

Accessible in this context means that the soil is present in the top 3 feet of the soil profile and in a form that roots can penetrate to obtain soil resources.

The Right Tree for the Right Site!

Tree selection must first consider available site soil volumes and second consider available canopy area. Likewise, site requirements need to match the cultural requirements of the tree or poor plant performance will result.

Why Protect the Urban Forest?

The Tree Canada Foundation http://www.tcf-fca.ca/ considers an urban forest to be the *"trees, forests, greenspace and related abiotic, biotic and cultural components in and around cities and communities. It includes trees, forest cover and related components in the surrounding rural areas."*

Humans are hardwired to need green environments. Studies have shown that people experience less stress in green environments when compared to sterile surroundings. They recover from illness quicker, have lower blood pressure, and are less likely to be violent or perpetrate crime in green environments.

Total Annual Benefits, Net Benefits, and Costs for Public Trees in Grande Prairie 2010 (I-Tree Streets software)

Total Benefits	$1,346,366
Total Costs	$ 758,947
Net Benefits	$ 587,419
Benefits $/tree	$ 91.23
Costs $/tree	$ 51.43
Net Benefits $/tree	$ 39.80
Benefits $/capita	$ 26.93
Costs $/capita	$ 15.18
Net benefits $/capita	$ 11.75
Benefit – cost ratio	**1.77**

A healthy Inner city street planting

The summary shows that for every $1.00 spent on tree maintenance urban residents receive back $1.77 in tangible and intangible benefits. Turf grass, shrubs, flowers and ground covers, also provide similar benefits, though in far lower quantities.

Summary of Urban Forest Benefits

- Storm water diversion and retention
- Air pollutant reductions
- Atmospheric cooling/urban heat island effect moderation
- Reduction in heating and cooling costs from wind protection and shading
- Sequestered carbon
- Urban humidity increased
- Green environments usually have lower rates of crime and violence
- Recuperating patients recover faster from illness. This results in health care savings
- Reduction in stress and increases in productivity and attention spans
- Provision of opportunities for outdoor activities to build a sense of community

Sidewalk replacement excavation

Why should Pest Management be concerned with Urban Forestry?

- Trees can live in excess of one hundred years and represent one of our longest enduring municipal assets. It makes fiscal sense to protect their health.
- The benefits provided by urban trees grow as the trees grow. One mature shade tree provides more benefits than 17 newly planted trees. Therefore, it is in the City's best interest to ensure that trees live to maturity. Canopy cover analysis can measure progress towards this goal.
- Pest management on urban trees represents the third most costly annual pest management program ($116,000). Changing standards to create more sustainable urban growing conditions will result in less need for monitoring and pesticide applications.

Recommendation 5: Tree Protection Bylaw

Create a Tree Protection Bylaw to moderate/eliminate damage created during development and redevelopment

Root and Crown Protection

Trees rely on healthy root conditions to provide the nutrient resources for sustained growth and vigour. A compromised root zone from compaction, construction, water logging, chemical imbalances or poisoning will result in a compromised tree.

Stressed trees are more susceptible to some disorders, insect and disease attacks.

Protecting the crown and root zone becomes crucial to maintaining the long-term health of trees. Bylaws produce stronger results than voluntary compliance.

Damaged wood emit scents, which may attract insect pests and provide entry for wind, water and vector borne diseases.

Example: Elm Pruning Ban

It is legislated in Alberta not to prune elm trees between April 1st and September 30th. During this time, elm bark beetles are flying and attracted to freshly cut elm wood. These beetles may carry Dutch Elm Disease (DED), a disease regulated for control under the Alberta Agricultural Pests Act. Therefore, management of the disease requires control of wounding to all elm trees. Construction damage or pruning cuts produce the same attractant scents and present the same risk to the tree.

Several different protection zone models are being used in Canada. It is prudent to research each model to determine the most appropriate one for use in Grande Prairie.

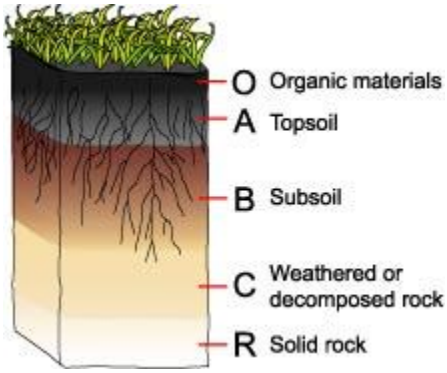
Recommendation 6: Critical Root Zone and Tree Protection Zone Standards and Specifications

1. **Create Critical Root Zone (CRZ) and Tree Protection Zone (TPZ) standards and specifications for redevelopments near public trees**
2. **Following consultation, incorporate specifications into the City Construction Manual**
3. **These specifications would prescribe a set process to be followed by stakeholders and City Departments**

SOIL PROTECTION

All terrestrial plants rely on soil either directly or indirectly for support and resources.

Soil is, *"a natural body consisting of layers, called horizons, of primarily mineral constituents, which differ from their parent materials in their texture, structure, consistency, color, chemical, biological and other physical characteristics".*



Graphic courtesy of the USDA.

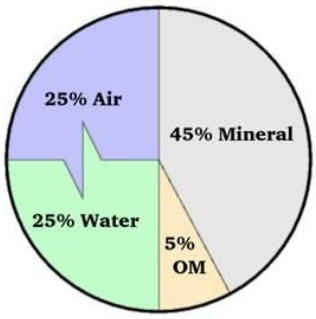
Soil is the dominant terrestrial ecosystem on the planet. All of our forests, grasslands and field crops depend on this ecosystem. Urban soils are typically disturbed type soils where the natural soil layers, called profiles, are often mixed during the construction process. While large projects strip topsoil prior to grading and excavation, small projects do not. Over time, this results in a patchwork of lower quality disturbed soils within any neighbourhood.

In general, when we keep landscape soils healthy most plants will survive. Healthy soil supplies what the soil microflora requires to live and these in turn supply much of what a plant needs to live.

By volume, a good quality soil is one that is 45% mineral (sand/silt/clay), 25% water, 25% air, and 5% organic material, both live and dead. These ratios vary slightly depending upon the organic matter content and the soil textural class (relative amount of sand, silt, clay).

Most plants (and the soil microbes that support them) are adapted to exchangeable soil atmospheres. If soil is compacted, it will lose pore space and therefore the amount of oxygen it can hold and conversely the amount of waste compounds like CO^2 that can move away from the roots. Root growth fails when only 10% oxygen by soil volume remains.

While reduced plant growth is observed in highly compacted soils, recent research is indicating that soil oxygen may not be the limiting factor but rather reduced hydraulic conductivity. As soil compacts, it becomes more difficult for water to move through the soil. Therefore adequate plant growth is possible in compacted soils but water resources must be highly managed. This degree of management is possible only with irrigated trees under constant scrutiny. It is better to alleviate soil compaction before planting than to highly manage water resources after planting.



The relative density of a soil can be determined by testing its Bulk Density.

Dry bulk density = mass of soil/ volume as a whole: $D_s = M_s / V_t$
This degree of density is measured in g/cm^3 of oven dried samples.

Table 8. Bulk Density by Soil Textural Classes (Adapted from NRCS Soil Quality Institute, 2000)

General relationship of soil bulk density to root growth based on soil texture			
Soil Texture	Ideal Bulk Density (g/cm^3)	Bulk densities that may affect root growth (g/cm^3)	Bulk densities that restrict root growth (g/cm^3)
Sands, loamy sands	<1.60	1.69	>1.80
Sandy loams, loams	<1.40	1.63	>1.80
Sandy clay loams	<1.40	1.60	>1.75
Loams, clay loams	<1.40	1.60	>1.75
Silts, silt loams	<1.30	1.60	>1.75
Silt loams, silty clay loams	<1.10	1.55	>1.65
Sandy clays, silty clays, clay loams (35-45% clay)	<1.10	1.49	>1.58
Clays (>45% clay)	<1.10	1.39	>1.47

Soil compaction, as expressed by bulk density, provides standardized quantitative measurements. Municipal standards for landscape soils would ensure that our urban plantings have the soil conditions necessary for a long productive life. Soil analysis is needed to determine soil density.

Soil supports life

CAUSES OF URBAN SOIL DAMAGE

- Pedestrian, equipment and vehicle traffic. The degree of compaction is determined by dividing the weight being carried by the surface area that contacts the ground.

TABLE 9. Ground Pressure by Agent

Compaction agent at rest	**Pounds per square inch of force**
Adult on snowshoes	0.5 psi
Tracked equipment	2-4 psi
Tracked skid steer loader	4-5 psi
Wheeled log skidder (floatation tires)	4-12 psi
Adult standing	6-8 psi
D6D dozer	8.7 psi
Light equipment on floatation tires	7-12 psi
Commercial tracked loader	9-12 psi
Skid steer loader with floatation tires	11 psi
Tree Harvester	6-17 psi
Wheel tractor scraper	21-44 psi
Passenger vehicles	25-30 psi
Horse	25 psi
Work truck	18-36 psi
Wheeled ATV	35 psi
Mountain bike	40 psi
Dump truck – 10 m^3 loaded	72-87 psi

Ground pressure is calculated by dividing the total mass carried by its contact area on the ground

- Ground pressure can increase dramatically if tire pressures are not maintained to manufacturer's specifications

- An average loam soil is 47% mineral, 25% water, 25% air and 3% organic matter (including organisms). Soil compaction occurs when a compressive force reduces the size of the air voids in a soil.
- Water entering the soil follows the large air voids to drain down deep. When these air voids become smaller, water infiltration is reduced and the soil is termed poorly drained. This compaction results in reduced soil oxygen.
- Soil oxygen is required for root and microbial respiration.
- About 80% of the total respiration in a forest comes from the soil microorganisms, not from the trees. Protecting the soil from compaction benefits the living soil matrix as well as the non-living structure.
- Almost every plant has evolved symbiotic relationships with soil borne fungi. These organisms excel at capturing soil resources for the plants in exchange for carbohydrates from the roots. Compacted conditions that harm roots also harm soil microbes.

Engineers use a proctor density test to determine the optimal moisture content at which a given soil type can be compacted to maximum density. Horticulture uses a bulk density test to determine the existing density of soil. These two industries do not talk the same language.

Both tests describe soil density to achieve different goals.

- Engineers need to determine what the maximum degree of compaction achievable is at this soil moisture content
- Landscape architects need to know the existing degree of soil compaction to determine if plants can grow there

This difference in terminology also reflects the inherent incompatibility of growing trees among hard infrastructure.

This incompatibility stems from:

- a mutual lack of understanding each other’s technical needs
- design constraints which do not provide adequate room for both to coexist

TABLE 10. Ocean County Soil Conservation District and Schnabel Engineering Associates Inc. NJ, 2001.

Permeability Measurements of Sampled Layers within 20 inches of Soil Surface								
Site	Disturbance	Dominant Soil Textural Class	**Ideal** Bulk Density (g/cm^3)	**Fair** Bulk Density (g/cm^3)	**Poor** Bulk Density (g/cm^3)	Bulk Density (g/cm^3) as tested *	Permeability (in/hr.)	Bulk Density (g/cm^3) surface 4"
Woods	Undisturbed	Sandy loam	<1.40	1.63	>1.80	1.42	18	1.18
Pasture	Somewhat disturbed	Loamy sand	<1.60	1.69	>1.80	1.47	9.9	1.28
Single House	Disturbed Light Equipment	Loamy sand	<1.60	1.69	>1.80	1.67	7.1	1.27
Subdivision Lawn 1	Disturbed	Loamy sand	<1.60	1.69	>1.80	1.79	0.14	1.50
Garage Lawn	Disturbed	Sandy loam	<1.40	1.63	>1.80	1.82	0.04	1.72
Cleared Woods	Disturbed Heavy Equipment	Loamy sand	<1.60	1.69	>1.80	1.83	0.13	1.75
Subdivision Lawn 2	Disturbed	Loamy sand	<1.60	1.69	>1.80	2.03	0.03	1.56
Athletic Field	Disturbed	Loamy sand	<1.60	1.69	>1.80	1.95	0.01	1.28

- Mean of three replications at seven locations
- Root restrictive growing environments

While this example is from the northeastern United States, the study is still relevant to Grande Prairie. Soil textural classes, soil permeability and the relationship between soil compaction and plant (root) growth are largely independent of geography.

Conclusions:

1. The relative soil density of the undisturbed and slightly disturbed sites was suitable for plant growth.
2. The smaller and lighter construction equipment (4-11 psi) used around the single house construction did not produce root restrictive soil compaction.
3. Larger grading equipment (21-44 psi) used on the subdivision, cleared woods and athletic field sites created root restrictive soil compaction.
4. The surface layer on all lawn areas and especially the athletic field had lower surface density figures. This is likely due to maintenance practices such as turf aeration, irrigation and fertilization. This reduced compaction did not carry down into the soils to a significant degree.

5. The tested native soils were sandy in texture. In Grande Prairie, native soils are predominately clay based in the north and centre with some silts and sands in the south. The literature indicates that soil compaction of clay soils is usually more severe.
6. Permeability to water infiltration was severely restricted on disturbed soils where heavy machinery was used during clearing and construction. This would impede water reaching plant roots and increase the amount of run-off.

Tine aerator on sports field

Implications for Grande Prairie Landscapes

1. Large-scale construction practices utilizing heavy equipment **are incompatible** with long-term tree growth where local soils are susceptible to compaction.
2. Small-scale construction practices using small equipment, while damaging, **are compatible** with long-term tree growth.

Recommendation 7: Soil Bulk Density Testing

Bulk Density testing is necessary to assess local soil compaction trends. These results should guide the re-drafting of applicable City Standards and Specifications.

1. **Test soil bulk density across land use types**
2. **Analyse bulk density data in relation to site soil textural class**
3. **Identify interdepartmental areas of conflict**
4. **Work with operational supervisors to control where salty snows are deposited and to reduce unintentional deposition of other waste products**

Land use types (adjacent to or in):

- Local Street
- Collector Street
- City Centre street
- Neighbourhood park
- Native Woodlots

Bulk density data analysis:

- Determine average bulk density by land use type
- Determine if there are correlations between land use type and soil compaction
- Determine probable causes for soil compaction
- Summarize finding and provide recommendations for avoidance

Interdepartmental areas of conflict:

- Prepare a process document which addresses communication in cross-over areas of responsibility
- Get buy-in from managers and operational staff

Work with operational supervisors:

- Brainstorm solutions
- Look for compromises
- Seek consensus

Existing infrastructure conflicts:

- Hard infrastructure and urban trees
- Development practices and soil quality
- Road salt and urban plant health

City Maintenance

Some City maintenance practices negatively affect urban plant health.

- Undirected traffic in green spaces
- Inadequate communication between City departments
- Unanticipated deposition of waste products
    - road salts
    - sedimentation, soils and building materials
    - pesticides

Recommendation 8: Soil Protection

Where possible:

Access to planting sites should be restricted for equipment listed in the shaded section of TABLE 9. Reviewed literature indicates that using equipment, which delivers these ground pressures, will create root limiting soil compaction

Where this is not possible:

Compacted soils should be subsoiled (deep cultivation 30 – 60 cm) to reduce compaction prior to top soil and tree installations. The goal of this cultivation is lessen subsoil compaction while preserving soil structure. Therefore, cultivate only to the point where large soil peds (10 - 20 cm) remain.

STANDARDS

Soil and plant sciences have objective, quantitative methods for determining crop requirements. City Standards and Specifications need to reflect these crop requirements.

Existing City Design Standards and Construction Specifications are sometimes inadequate at providing suitable growing environments at tree planting sites. This often results in trees that grow poorly and are less likely to tolerate minor pest attacks.

Recommendation 9: Follow-up and Consultation

1. **Review the soil science data resulting from Recommendation 6 and report results to the Community Living Committee for direction**
2. **Assess current service levels against public needs and opinions data results from Recommendation 1 and report to the Community Living Committee**
3. **Assess Customer Survey information to assess if changes to City Standards and Specifications are required for environmental stewardship and general welfare. Report to the Community Living Committee for direction**
4. **Follow established consultation procedures with local stakeholders**

PROTECTING UNDISTURBED SOILS

Bear Creek corridor

It is important to protect native soil profiles from disturbance and compaction. Compaction avoidance and minimization strategies include:

- Controlling traffic directions and paths to limit compaction to a smaller area
- Basing allowable levels of compaction on the needs of the crop growing there
- Using properly inflated tires
- Using tracked equipment to reduce ground pressure and therefore compaction

Every living thing we see around us relies, either directly or indirectly, on soil health. Soil is the pillar that supports all life on land.

MAINTAINING SOIL HEALTH

Soil will remain productive if urban soils are protected from compaction and appropriate management of the green space is followed.

Tips to maintain soil health:

- Minimize and control where snow is stockpiled. This snow carries road salts that enter the soil each spring causing soil de-flocculation resulting in soil compaction.
- Replace lost organic matter content by incorporating leaf litter, compost or (seed free) grass clippings into exposed soil. Approximately 20% of soil organic matter content originates from leaf litter residues.
- Aerate and top-dress turf grass with soil and organic matter blends
- Apply organic mulches over tree and shrub root zones
- Ensure proper drainage to protect the matrix of microorganisms living in the soil
- Replace the use of inorganic fertilizers at high rates with organic based fertilizers at low rates (except on flower beds)
- Avoid the application of pesticide directly to the soil including soil sterilants and drenches

RENOVATE SOILS

Disturbed or compacted soils require human intervention to correct the structural damage before they may become productive again. Techniques include:

- Analyse the soil to determine:
    - Particle size analysis (the ratio of sand/silt/clay particles)
    - OM (% organic matter content)
    - pH (acidity)
    - EC (salts)
    - SAR (sodium adsorption ratio)
    - NPK (existing nutrient levels in the soil)
- Base all management actions on the results of the soil analysis coupled with the utility of the site
- Incorporate organic matter into the soil to:
    - reduce soil density
    - increase aeration porosity
    - improve the water and nutrient holding capacity
    - aid the development of aggregation and soil peds.

- Reduce compaction by cultivating or using a tine or core aerator

BUILDING AND PROTECTING HABITATS

Habitat protection and species diversity is fundamental to reducing pesticide use in urban settings.

Riparian habitat along Bear Creek

The Bear Creek corridor is both a recreation and wildlife corridor. It encompasses over 165 hectares of natural and naturalized woodlands. This includes roads, trails with bridges and meadow, forest and riparian habitats. These habitats contain complex food chains running from soil microbes all the way up to primary predators.

Its soil holds a matrix of animals, fungi and bacteria, which cycle nutrients from the forest floor to the root zone of vegetation.

This area cycles water, reducing run-off to local storm systems. A 2.5 cm (one-inch) rain event over the entire corridor would intercept 41,250 m^2 (9,073,731 imperial gallons) of water. On a hot summer day, foliage transpires thousands of gallons of water, raising local relative humidity.

Native plants are rarely planted in residential yards and thus native wildlife is seldom attracted to our planned landscapes. Food chains are impaired at this interface and this disconnectedness deters species diversity in our back yards.

Generalist feeders like deer, squirrels, ants, songbirds and spiders will cross over into our built environments for food or habitat. Organisms that are host specific to native plants will not. Nor will the animals that feed only on these herbivores.

To bring nature back to our back yards we need to incorporate native plants into our landscapes. Native plants that produce seed or fruit are good choices.

Species diversity is hard to observe in natural areas. Many organisms are small, hidden or nondescript, yet they are valuable links in the food web. People may not see them but the health of the landscape relies on them.

As many native plants cannot compete aesthetically with more attractive garden centre plants, the move should begin by incorporating native woodlots into new developments. These woodlots bring a wellness experience that cannot be duplicated with traditional landscape designs. Tree-free buffers from property lines are required to accommodate trees that fall during succession and access must be maintained for periodic maintenance.

Incorporating naturalized woodlots and plantings into urban development will increase species diversity and decrease the need for pest control.

Woodlot in Mountview

Native species should be used more in public landscapes. Public education campaigns can encourage the use of native plants on private lands.

Did you know that the transition from barren new housing developments to a green, living neighbourhood typically takes between 20 and 30 years?

It takes this time for local plantings (public and private), to grow large and diverse enough to attract and support a variety of animals (insects, spiders, squirrels and birds). As these landscapes mature, the complexity of this urban ecosystem grows. While it may be composed of many alien insect and plant species, it is still preferable to a new built environment. It also presents an opportunity to integrate native plant species. These will attract native insect herbivores, which in turn will attract songbirds.

Facilitating the development of a diverse ecosystem will improve the quality of life for our residents and the health of our urban environment. It is a manifold effect, increased species diversity, less pesticide use, healthier urban environments, and more opportunities for youth activity.

Traditional landscape design focuses on building aesthetically pleasing plantings that are easy to maintain. The move to a landscape design system geared to create sustainable ecosystems requires both a different mind-set and a different set of goals and skills. It requires a paradigm shift.

It would be practical to rely on traditional landscapes designs built with more sustainable plant materials and construction techniques. By adding native woodlots and sustainable built landscapes into each new development, an acceptable blend of wild and manicured landscapes would form the urban greenspace. Bring nature back into our neighbourhoods and natural pest control animals will follow.

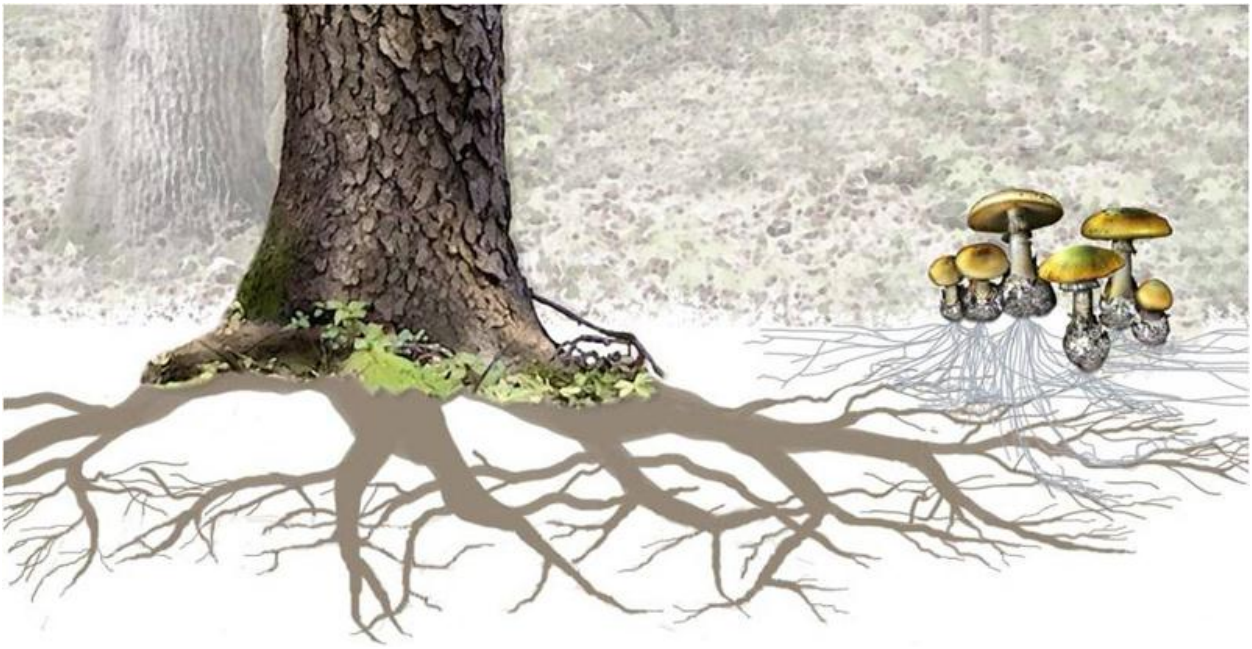
Literature suggests that a minimum parcel size of 0.4 hectares will protect species diversity provided there are contiguous connections between native areas. This parcel size is close to the size our existing neighbourhood park standards. It is likely that some hybrid version of a native woodlot is adaptable to our building practices.

There is a cost to this landscape ethic. Need should be assessed by what our customers find important and what is in the best interests of our community. Action Item 7: Survey and Response will provide the information necessary to weigh these values and needs.

THE MYCORRHIZAL WEBS

Mycorrhizae are fungi that grow in association with the roots of a plant, in symbiotic or rarely mildly pathogenic relationships. There are many different species of mycorrhizae, which colonize most plants including the grasses, forbs and trees. Mycorrhizae provide about 30% of the carbon storage in a soil and are a major part of the soil food web.

These fungi colonize tree roots and share the water, elements and minerals that they obtain from the soil. In exchange, the fungi receives sugars from the tree. Mycorrhizal threads have exponentially larger surface areas than tree roots alone and are able to capture significantly more soil resources. Therefore, the tree benefits from a vastly increased soil resource stream, while the fungi benefit from the superior carbohydrate production system of the photosynthesizing tree foliage.



Simplified relationship of mycorrhizae and tree roots

Photo courtesy of Shannon-Wright, UBC Gardens
http://www.botanicalgarden.ubc.ca/

Mycorrhizae and plant root relationships have been studied for more than 120 years. Today we understand that 95% of all plant families rely upon these fungal relationships for survival. These relationships are so integral to the prosperity of both the plants and the fungi that both groups demonstrate an evolutionary advantage from this relationship.

Current research indicates that mycorrhizae create fungal webs linking plants together. This web allows plant resources to move from plants with surplus resource elements to plants low in resource elements.

While tree root grafting (between roots of adjacent plants) is largely restricted to plants of the same genus (birch to birch), Mycorrhizae are sometimes able to form a bridge between different plant families (birch to douglas fir).

Carbon and nitrogen moves from mature (hub) trees, along these pathways to young plants or to those too shaded by the canopy to gain the resources needed for steady growth. Protecting the old hub trees then becomes vital to providing for the next generations of trees.

Research is just starting to investigate the prevalence of this web, what evolutionary advantages there are to interspecies-shared resources and the relations that are possible.

When assessing urban development methods several things become evident:

1. Housing development may take place on lands that were fallow, under agriculture or under forest. Therefore, very different soil biotic communities may be in place. Not all soil biota benefit all plant species. For example, grasses thrive in bacteria dominated soil ecologies and trees in fungi dominated soil ecologies.
2. Large-scale construction practices typically remove all trees while working on subsoil grading and utilities. Tree removal and soil disturbance will damage existing rhizosphere ecosystems including mycorrhizal food webs. This is inevitable however; the question becomes what is feasible to minimize this damage?
3. Hub trees are seldom preserved to act as resource trees for newly planted urban trees. Re-establishment of mycorrhizal networks would be quicker if some mature trees were left on site to aid the recovery.
4. While some mychorrhizae are still present, it will take time for a new web to become established.
5. The grass growing under a tree has very different microbial needs than the tree itself. This is just one of the many reasons that trees benefit when turf grass is removed from beneath the canopy.
6. The loss of the mycorrhizal web or any construction practices that damage the soil conditions favourable to mycorrhizal proliferation, will adversely affect trees in new subdivision constructions.

PUBLIC OPINIONS SURVEY SUMMARY

2007 Pesticide Opinions Survey

Of the 353 respondents, the results indicated that:

- 59% of those surveyed had some concerns about the use of pesticides in and around the City while 33% indicated it was not a concern.
- On average 60% of respondents were in favour of City pest control programs.
- 42% of respondents believed that the City should only use alternatives to pesticides while 48% disagreed.

Survey question results from 2007 Opinions Survey versus the Parks Masterplan Question may indicate an ongoing public opinion swing away from pesticide use in Grande Prairie.

2012 Parks Masterplan Survey

Statement was made:

"I support City Councils 2008 decision for Parks Operations to discontinue the use of pesticides for cosmetic control of broadleaf weeds (including dandelions) on city maintained properties (parks, boulevards, public utility lots etc.)."

Of the 384 respondents the results were:

- Strongly Agree 34.6%
- Agree 27.6%
- Neither agree nor disagree 16.2%
- Disagree 14.3%
- Strongly disagree 7.3%

The results indicated that 62.2% supported this decision while only 21.6% did not support this decision. This is a strong indication that local opinions are against the cosmetic use of pesticides. A further 16% skipped the question, which may indicate that they did not feel strongly for or against the decision.

2012 City of Grande Prairie Pest Management Survey

The mandate of the IPM Plan is to direct pest management activities over the next 10 years.

This plan is largely operational in nature and based on current research, industry standard best practices and professional experience. With this in mind, public input was solicited largely to gauge the customers' understanding of pesticide issues, their opinions and needs.

Surveys were distributed on the City of Grande Prairie website, at the 2012 Home Show, at the 2012 Municipal Government Day celebrations and by hand to each city neighbourhood. An equal number of surveys were delivered to each neighbourhood, independent of population.

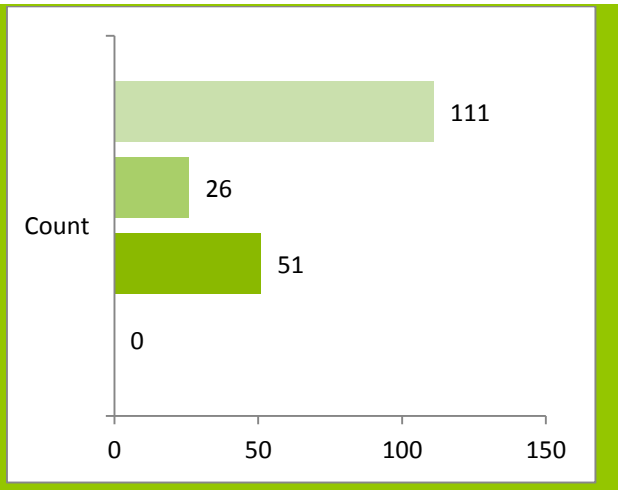
SUMMARY OF RESULTS

The survey was set up using a Likert even-point scale, running from strongly agree to strongly disagree. 190 surveys were completed; however not all respondents completed all the questions.

PUBLIC KNOWLEDGE QUESTIONS

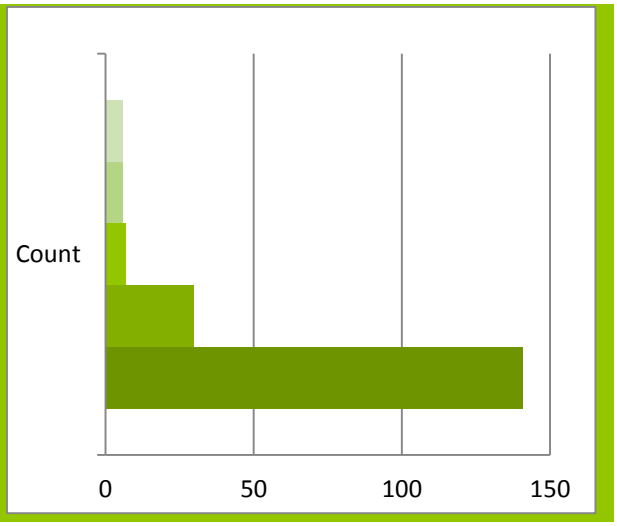
1. WHAT IS A PEST?

Response	Count	Percentage
Living things that interfere with people and their activities	111	59%
Living things that are out of place	26	14%
Bugs and weeds	51	27%
I don't know	0	0%
Grand Total	188	100%



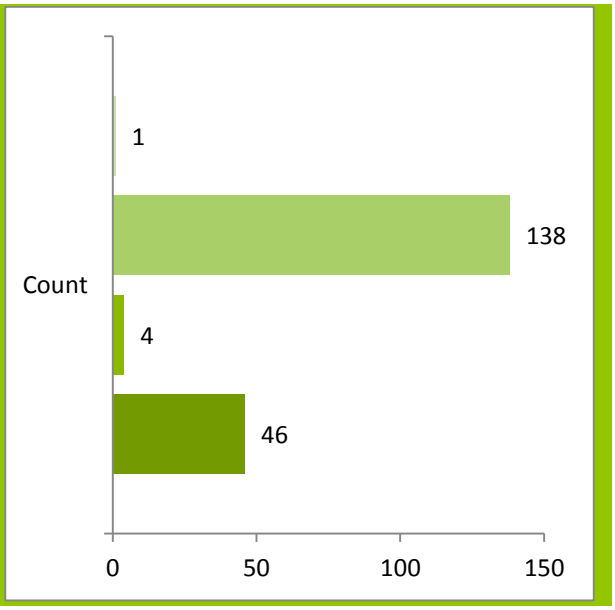
2. WHO DECIDES WHICH THINGS ARE PESTS?

Response	Count	Percentage
The individual	6	3%
The community	6	3%
I don't know	7	4%
Government – Local, Provincial and Federal	30	16%
All of the above	141	74%
Grand Total	190	100%



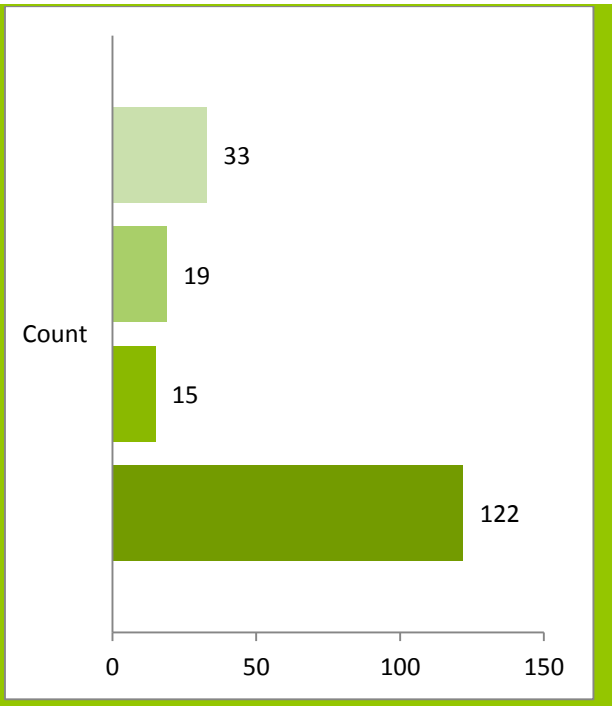
3. WHAT IS A PESTICIDE?

What is a pesticide?	Count	Percentage
I don't know	1	1%
Any substance used to prevent, kill or repel a pest	138	73%
Botanical and natural products used to kill pests	4	2%
Synthetic chemicals used to kill insects	46	24%
Grand Total	189	100%



4. COSMETIC PESTICIDE USE REFERS TO?

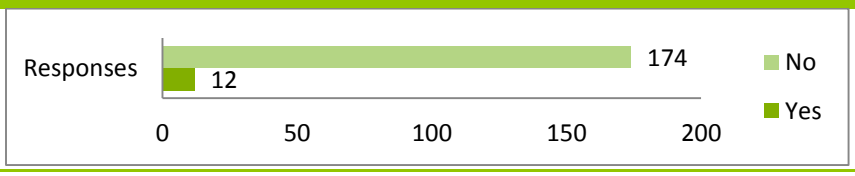
Response	Count	Percentage
I don’t know	33	17%
Pesticides applied to disguise visible pests	19	10%
The use of natural and botanical pesticides	15	8%
Pesticides applied to improve appearance, not to protect health	122	65%
Grand Total	189	100%



GENERAL OPINION QUESTIONS

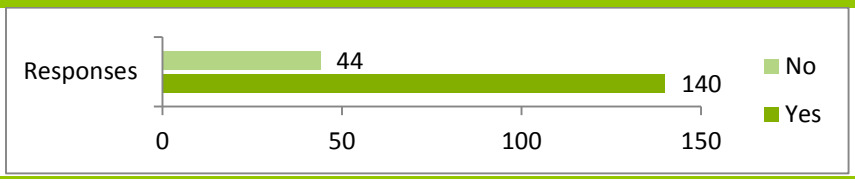
1. TO MAINTAIN A HEALTHY LAWN, YOU MUST USE CHEMICAL PESTICIDES.

	Responses	Percentage
No	174	93.5%
Yes	12	6.5%
Total	186	100%



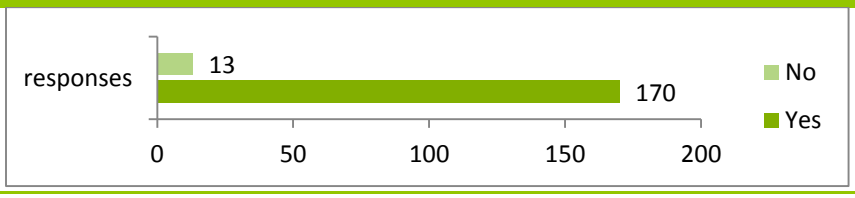
2. PESTICIDES SHOULD ONLY BE USED ON LAWN WHEN OTHER METHODS OF PEST CONTROL HAVE FAILED.

	Responses	Percentage
No	44	23.9%
Yes	140	76.1%
Total	184	100%



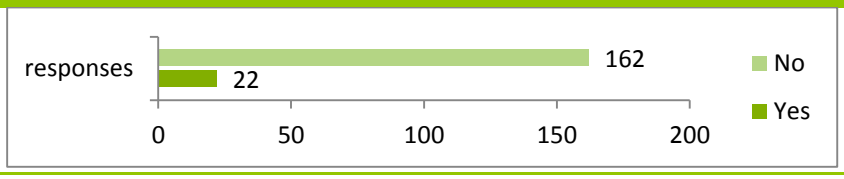
3. DO YOU BELIEVE THE CITY OF GRANDE PRAIRIE SHOULD CONDUCT PEST CONTROL ACTIVITIES?

	Responses	Percentage
No	13	7.1%
Yes	170	92.9%
Total	183	100%



4. HAVE YOU EVER CONTACTED THE CITY OF GRANDE PRAIRIE TO REQUEST PEST CONTROL ON CITY LANDS?

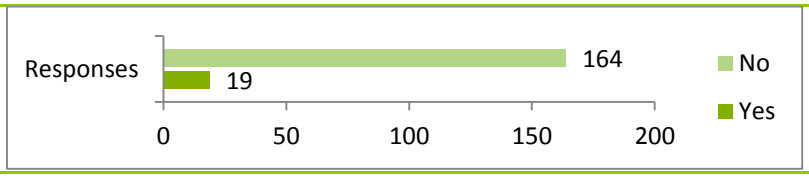
	Responses	Percentage
No	162	88%
Yes	22	12%
Total	184	100%



5. HAVE YOU EVER CONTACTED THE CITY OF GRANDE PRAIRIE TO REQUEST ADVICE CONCERNING PEST PROBLEMS AT YOUR HOME?

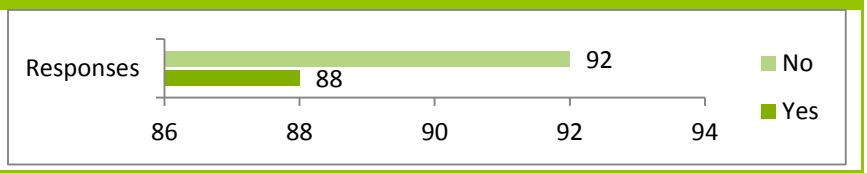
	Responses	Percentage

No	164	89.6%
Yes	19	10.4%
Total	183	100%



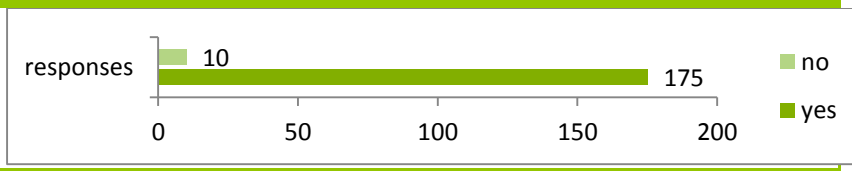
6. DO YOU THINK THE CITY OF GRANDE PRAIRIE NEEDS A LAW RESTRICTING PESTICIDE USE?

	Responses	Percentage
No	92	51.1%
Yes	88	48.9%
Total	180	100%



7. DO YOU BELIEVE IT IS IMPORTANT TO CONTROL PEST INSECTS ON TREES?

	Responses	Percentage
No	10	5.4%
Yes	175	94.6%
Total	185	100%



GENERAL NEEDS QUESTIONS

PESTICIDE PREFERENCE

On a scale from 1-4, with 1 being LOW COST CHEMICAL PESTICIDE and 4 being MORE EXPENSIVE, ENVIRONMENTALLY FRIENDLY PRODUCTS, where do you believe the City should set its target for pest control operations?

	Responses	Percentage
I don't know	20	10.5%
4 – expensive	46	24.2%
3	83	44.0%
2	33	17.0%
1 – low cost	8	4.0%
Total Responses	190	100.0%

TELL US WHAT YOU THINK

	I don't	1	2	3	4	Total

	know					Responses
Mosquito Control	59 (31%)	23 (12%)	28 (15%)	56 (29%)	24 (13%)	190
Noxious Weeds	60 (32%)	35 (18%)	32 (17%)	43 (23%)	20 (11%)	190
Tree Pest and Diseases	77 (41%)	8 (4%)	28 (15%)	55 (29%)	22 (12%)	190

On a scale from 1-4, with one being NOT EFFECTIVE and four being VERY EFFECTIVE, please rate the City's pest control activities.

GREEN SPACE AND WEED CONTROL

On a scale from 1-4, with one being NOT IMPORTANT and four being VERY IMPORTANT, how important is it to you that City green space is weed free?

	Responses	Percentage
I don't know	12	6%
4 – very important	62	33%
3	60	32%
2	34	18%
1 – not important	22	12%
Total Responses	190	100%

ADDITIONAL COMMENTS

There were 51 responses to this question, 10 people said that they did not live in the City of Grande Prairie. The remaining 41 responses fit into six categories: complaints, education, opinions, positive feedback, questions and statements.

COMPLAINTS

- City has a lot of noxious weeds in back alleys and empty lots.
- All I know is that when the City was spraying for weeds, I was able to keep my lawn almost weed free, with regular use of weed 'n' feed and now it's a disaster.
- We can keep working hard and trying to maintain a lovely grass yard but more than half of Grande Prairie residence do not care or maintain their yards so their weeds and dandelions blow into our yard. It is very embarrassing for anyone trying to have pride in his or her property or trying to sell.
- This City is horribly overrun with weeds! The sea of yellow each year is sickening and for homeowners who take pride in their yard it is a losing battle! Please address this issue!
- Many uncut lawns around this area some were as high as 18" this year C/W thistle.
- It would be great if the weed inspectors actually did something. There is scentless chamomile in my area on people's properties and NOTHING is ever done about it.
- The City of Grande Prairie has a horrible noxious weed problem. It needs to start abiding by provincial legislation and start enforcing control of these particular weeds on both public and private lands. The Alberta Weed Act has been implicated for a reason and the city really needs to do a much better job of both controlling their own weed problems and enforcing the weed control act and educating the public about noxious weeds. Any other pest control is neither here nor there.
- Living close to an easement there has been no involvement from the City as to its upkeep - weeds are prevalent and add to problems as a homeowner to battle - thistle, dandelions are prevalent. The City only mowed the easement once last year and only partially.
- Work at maintaining an effective pest control program, noxious weeds like scentless chamomile are not being effectively controlled. It is very important to have our green spaces i.e. utility lanes, ditches and parks looking good with health vegetation.

EDUCATION

- Encourage home owners to report pests with more advertising as what to spot (weeds), tree disease etc. and what to do - treat it yourself (+how), - report, where Offer alternatives if home owners don't like chemicals. What's available?
- To bring information and educate people on the use, risk and benefits of pest and pesticides

OPINIONS

- Think City should continue to spray dandelions and mosquitoes.
- Chemical pesticides is the cheapest and most effective way to maintain a healthy lawn and used properly they are not harmful to the environment.
- With respect to question 3. I believe noxious weeds should be controlled but other weeds should just be cut or pulled. I prefer the use of environmentally friendly pesticides and herbicides whenever possible.
- We prefer environmentally friendly products - we have dogs and grandchildren. To certain extent, yes we need a law restricting pesticide use.
- Public not aware pesticides are herbicides + insecticides + fungicides. Some not toxic at all and some very toxic. City must control weeds like mayweed + thistle on all lands. City listens to environmentalists and other uninformed people too much. Thy usually have other agendas.
- Protecting our population from harmful pesticides should be no 1 priority
- You need to enforce the care of lawns to prevent the spread of weeds.
- My biggest issue is too many cats in the hillside area 105 avenue. They are the pests
- Mosquitos are out of control in Grande Prairie and surrounding area. The decrease in pesticide use has allowed Bed Bugs to once again become a large problem. Dandelions everywhere is not acceptable to me, I would rather use pesticides than have our green spaces turned yellow.
- I think it's important for the City to find a balance between effective pest management of MOSQUITOES & noxious weeds and environmentally friendly products. Lots of natural products do not work very well and lots of highly effective chemicals are too harsh for our kids/earth/pets.
- Ants are a problem for people in Mission Heights, with large hills in the vicinity of 102Street backing onto Bear Creek. We need to find some way to control these insects before they become a wide spread problem.
- Besides controlling mosquitos, the city should control the growth of dandelions on city property.

- Dandelion seeds flying are a pest for people who have allergies and try to keep their lawns free of dandelions.
- City should do minimal pest control. City green space should be natural but clean.
- Keeping the City beautiful gives its residence pride in its city and visitors are given a positive impact.
- Mosquito control is very important since west Nile virus
- Dandelions and clover are a fact of life. Thistle and mayweed should be controlled.
- It has been very good during the 8 years I have resided here. However, many forms of pesticide have now been banned and we are looking at an increase of pests due to this. Strong measures should be taken as many of these pests invasively affect people's homes and lifestyles.
- Since I have only lived here for 1 ¾ years, I am not that familiar with what is being done regarding pest control. What I have noticed a lot of lawns do not seem to be cut at least this past summer on a regular basis. Whether that would have an effect I do not know to be honest but I think it would make the neighborhood look much more inviting with nicely cut lawns.
- When the city controlled weeds on greenscapes, I had no problem controlling weeds in my yard without using chemicals. RE #7 under Managing Pests, trees take so long to mature and provide so many benefits; it is prudent to control pests.
- I love birds, never use any chemical/pesticides in my yard. I worry about all natural things and the air we breathe of course. I don't like mosquito, I feel we all need to play a part in making sure we don't leave standing water around to encourage their breeding.

POSITIVE FEEDBACK

- Did a great job on pine beetles in the city. Good mosquito control program.
- On the occasion of requiring information on noxious weeds or pesticides the Parks Department has been very helpful.
- I bought a house in the winter because it had large birch trees. It now appears that the birch trees are dead and I suspect it is due to Birch Borer. I now have to cut them down and replace with saplings. What is left of the trees is affected by aphids. I love the city website, and wish it had more on tree and shrub planting

QUESTIONS

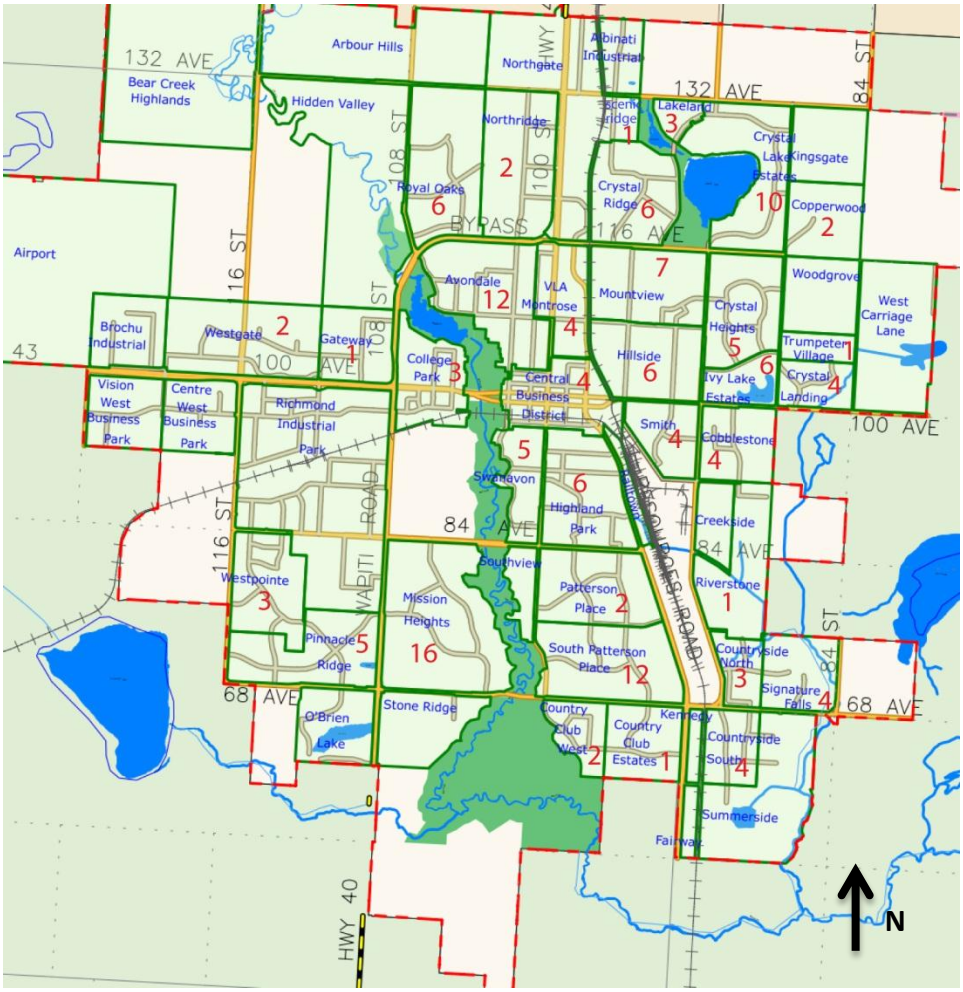
- Definition of Weed?
- I wonder if the city has a policy for apartment bed bug control, and if a subsidy is offered to landlords to treat bed bug infestations?
- What does "RESTRICTING" mean in a bylaw? Need enforcement of weed control act and/or bylaws especially on vacant commercial properties.
- Why is the only option presented in your survey thus far pesticides? This is the last option in an integrated pest management plan.

STATEMENTS

- Please do not go overboard on expensive environmental products, keep happy balance between cost- effectiveness - environment.
- All though I would love to use the green space of our city without being bugged by pests or noxious smells from weeds I would much rather support was is sustainable and will leave a green space that is healthy for the future generations.

DEMOGRAPHICS

RESPONDENT'S NEIGHBOURHOODS



Four neighbourhoods had participation rates of five percent or higher:

- Avondale (6%),
- Crystal Lake Estates (5%),
- Mission Heights (9%),
- South Patterson Place (6%).

There were a large number of respondents, 14 percent, who provided no information.

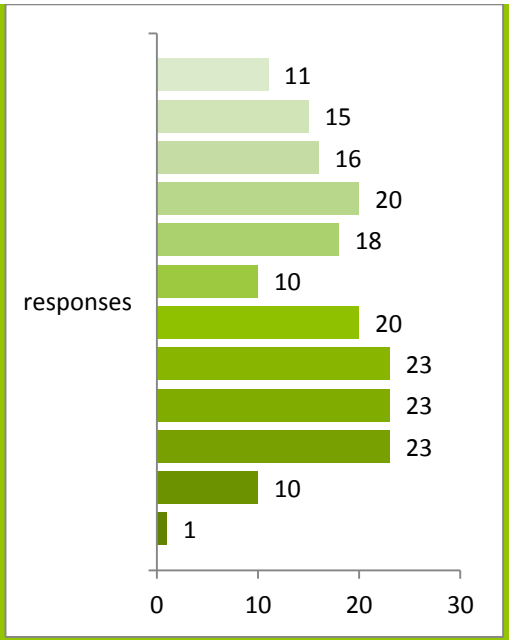
Responses	Count	Percentage
Avondale	12	6%
Coachman Village	0	0%
Cobblestone	4	2%
College Park	3	2%
Copperwood	2	1%
Country Club Estates	1	1%
Country Club West	2	1%
Countryside North	3	2%
Countryside South	4	2%
Creekside	0	0%
Crystal Heights	5	3%
Crystal Lake Estates	10	5%
Crystal Landing	4	2%
Crystal Ridge	6	3%
Downtown	4	2%

Responses	Count	Percentage
Gateway	1	1%
Highland Park	6	3%
Hillside	6	3%
Ivy Lake Estates	6	3%
Lakeland	3	2%
Mission Heights	16	9%
Morgan Meadows	0	0%
Mountview	7	4%
North Patterson Place	2	1%
Northridge	2	1%
O'Brien Lake	0	0%
Pinnacle Ridge	5	3%
Riverstone	1	1%
Royal Oaks	6	3%
Scenic Ridge	3	2%

Responses	Count	Percentage
Signature Falls	4	2%
Smith	4	2%
South Patterson Place	12	6%
Summerside	0	0%
Summit	0	0%
Swanavon	5	3%
Trumpeter Village	1	1%
Veterans Land Allocation	4	2%
Westgate	2	1%
Westpointe	3	2%
No Response	26	14%
Totals	185	100%

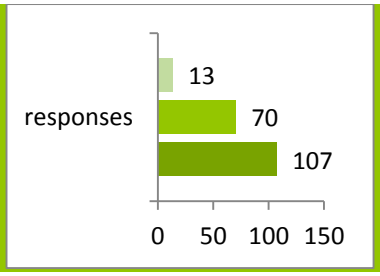
AGE RANGE

Age	Responses	Percentages
No Answer	11	6%
>64	15	8%
60-64	16	8%
55-59	20	11%
50-54	18	9%
45-49	10	5%
40-44	20	11%
35-39	23	12%
30-34	23	12%
25-29	23	12%
20-24	10	5%
15-19	1	1%
Total	190	100%



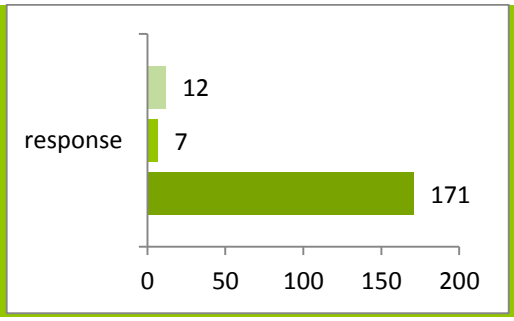
GENDER

Gender	Responses	Percentage
No answer	13	7%
Male	70	37%
female	107	56%
Total	190	100%



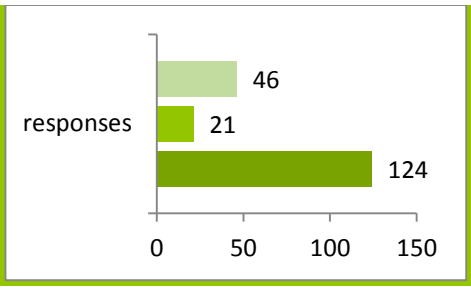
DO YOU LIVE IN A HOUSE OR APARTMENT?

	Responses	Percentage
No answer	12	6%
Apartment	7	4%
House	171	90%
Total	190	100%



DO YOU OWN OR RENT YOUR RESIDENCE?

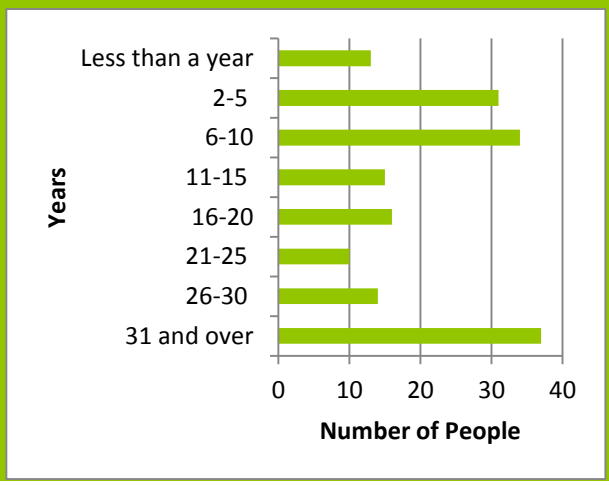
	Responses	Percentage
No answer	45	24%
Renter	21	11%
Owner	124	65%
Total	190	100%



HOW LONG HAVE YOU LIVED IN GRANDE PRAIRIE

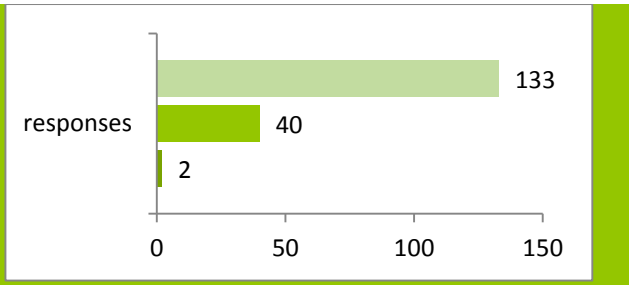
170 people provided a response, of those who responded 46 percent have lived in Grande Prairie for less than 10 years.

Length of time	Responses	Percentage
Less than a year	13	8 %
2-5 years	31	18%
6-10 years	34	20%
11-15 years	15	9%
16-20 years	16	9%
21-25 Years	10	6%
26-30 Years	14	8%
31 Years and over	37	22%
Total	170	100%



DID THIS QUESTIONNAIRE MAKE SENSE TO YOU?

	Responses	Percentage
Yes	133	76 %
Somewhat	40	23%
No	2	1%
Total	175	100%



Survey Response Analysis

Questions relating to Public Knowledge

- Responses indicated a reasonable understanding of basic pest and pest control issues.

Questions relating to General Opinions

Questions relating to General Needs

- Respondents were asked:
  "On a scale from 1-4, with 1 being LOW COST CHEMICAL PESTICIDE and 4 being MORE EXPENSIVE, ENVIRONMENTALLY FRIENDLY PRODUCTS, where do you believe the City should set its target for pest control operations?"

  66.2% of respondents indicated that the City should use expensive or somewhat expensive ecologically friendly products. While 21% indicated that, the City should use low cost or somewhat lower cost chemical pesticides. 10.5% or respondents were undecided.

- When asked to rate City pest control services, an average of 39% of respondents (59% excluding the undecided) thought they were very effective or effective. While an average of 27% of respondents (41% excluding the undecided) thought, they were not effective or somewhat ineffective. The remaining average of 34% did not know.

  Such a high percentage of customers without opinions regarding this topic may indicate a disinterest in the topic, or it could indicate a communication disconnect between City Services and the customers. Possible reasons for the latter include:
  - Pest control operations are often scheduled to avoid the public (risk mitigation)
  - Many pest control operations occur in unpopulated or lightly populated areas such as the Bear Creek corridor or along gravelled roads near municipal boundaries.
  - Many communication strategies are too targeted or too pest specific.
  - Some formats do not provide reliable media coverage.

  The implementation of Action Item 7: Public Education should address both the communication and public relation issues.

- Respondents were asked:
  "On a scale from 1-4, with one being NOT IMPORTANT and four being VERY IMPORTANT, how important is it to you that City green space is weed free?"

65% of respondents replied that it was very important or important that City green spaces be weed free. While 30% indicated, it was not important or somewhat unimportant. 6% were undecided.

This result would appear to be a contradiction to opinions regarding residential lawns, where respondents were not in favour of pesticide use.
One possible conclusion is that while the majority of homeowners do not want pesticides used on their residential lawn they still want dandelion control on City lands. Similar opinions were voiced in customer comments.

This result also conflicts with the answer to the 2012 Parks Masterplan question in which 62.2% of respondents either agreed or strongly agreed to City Councils decision to discontinue cosmetic dandelion control on (the majority) of City green spaces.

Possible explanations for this include:

- limited survey sample size
- skewing due to an unequal number of responses from each neighbourhood, which may weight in favour of demographics such as neighbourhood age

190 survey responses, while provides a reasonable sampling of customer attitudes, should not be considered as statistically significant. These results may indicate local attitudes but sample error should be considered too high for significance.

BALANCING PUBLIC OPINION WITH ENVIRONMENTAL STEWARDSHIP

City operations exist both to provide the services that urban dwellers require and to provide expertise capable of protecting the general welfare of its residents. This dual role means that municipalities must both build safe road and enforce traffic regulations on these roads.

City Integrated Pest Management performs pest control activities while keeping in mind the general welfare of its citizens.

Pest control operations must weigh difficult questions:

- *"How many mosquitoes are too many? If we control these, how will this affect the local environment?"*
- *"Do they (public) need this or just want this?"*
- *"At what point does environmental health supersede aesthetics?"*
- *"Is that infested tree at risk of dying or is it healthy and just looks unpleasant to its neighbours?"*
- *"Do we intercede or let nature takes its course?"*

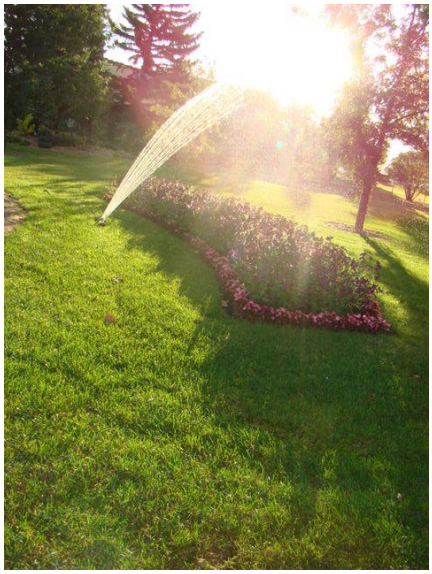
Customer Opinions Surveys are important tools that ensure that City services align with public needs, provided that actions fall within the context of the greater stewardship role.

"Primum non nocere" *First, do no harm.*

FUTURE PROJECTIONS

- Climate Trends
- Urban Forest Implications
- Invasive Alien Species
- Pest Control Programs
- Regulatory Changes
- Public Opinion Trends

CLIMATE TRENDS



Flowers irrigated in early morning

There is a direct link between climate and all forms of life. This link is habitat and resource driven. Plants and animals are adapted to climates where they evolved. When local climate changes, local organisms are affected. Therefore projecting how the future climate will change is important to our understanding of how this affects our living environment.

The role of IPM is to protect the health of our urban landscapes and control nuisance pests that bother our residents. Even a single unusual climate year can have dramatic effects on our urban trees. These can carry-over into the next few growing seasons.

Climate Trend Summary

Analysis of Alberta Temperature Observations and Estimates by Global Climate Models. Alberta Environment

> ***"Over the 1960-1995 period, the greatest warming trend was found in Beaverlodge, where the mean temperature increased 0.56°C/decade, giving an overall warming of 2.0°C, over the 36-year period."***

Over this same period, the Grande Prairie warming trend was 0.42°C/decade or 1.87°C over 36-year period.

This study data covered the period from 1938 – 1995. While past trends do not guarantee future trends, Environment Canada data since 1995 shows a general continuation of this trend. Projected forward this **could** result in a further 3.3°C increase in temperature by century end. However, forward projections are reliant on a continuation of past trends. In addition, there is no way to know if warming trends are just part of longer-term (multi-century) warming/cooling trends.

In reality, climate is very complex and it is impossible to say with certainty if the planet will warm over this period. There will likely be too many divergent years over the 10-year plan relevancy period to draw many useful conclusions over such a short time period.

Droughts

On average, the Canadian prairies experience a multi-year drought about every twenty years. The last such drought was between 1999 and 2005. It is unlikely that Grande Prairie will experience another major drought during the 10-year relevance period of this plan.

However, the after effects of a prolonged drought cycle on the biotic communities are experienced for many years following the event. Grande Prairie's urban forest still shows signs of outbreak attacks that occurred during the last drought cycle.

The western ash bark beetle (WABB) and the bronze birch borer (BBB) are still in moderate numbers across the region. Neither of these insects were considered a pest here until the last drought cycle. BBB has killed hundreds of local birch trees. Deadwood created by the WABB activities has severely affected the aesthetic value of hundreds of ash trees and burdened City arborists with ongoing pruning and removal work.

URBAN FOREST IMPLICATIONS

Tree ring analysis shows that prairie drought cycles occur with regularity.

The summary document Climate Impacts on Canada's Prairie Provinces: A Summary of our State of Knowledge by the Prairie Adaptation Research Collaborative came to these conclusions:

- Prairie climate is becoming warmer and drier
- Less moisture will be stored as winter ice and snow
- Much of the anticipated temperature increase will be in the winter and spring
- Stream and lake levels will drop due to decreased winter precipitation
- Soil moisture levels will continue to fall
- Some forest and agricultural pests may survive milder winters
- Some vector-borne diseases such as West Nile virus and Hantavirus could become more common.

Over the 10-year relevance period of this plan:

- Possible temperature increase of 0.42°C:
    - A warming trend will not adversely affect most urban trees. The majority of the urban forest resides on private, residential lots. In general, residential trees are healthier than Public Park or arterial boulevard trees.
    - Increasing temperatures, when combined with periodic stress factors such as prolonged drought, heat stress and excessive wind velocities, could make trees growing in poor locations more susceptible to some insect attacks.
    - Grande Prairie might move from Canadian Plant Hardiness Zone 2B to (the equivalent of) zone 3A. This could lead to a greater range of plant species planted in Grande Prairie. A broader range of plants could result in new pest introductions and a broader range of pest organisms.
    - Warmer temperatures require higher levels of precipitation to maintain healthy trees and shrubs. While expected temperature increases are minimal, during drier summers, local trees will suffer water stress earlier.
    - Successive years of water stress leads to changes to the chemical messages emitted by stressed trees. This can lead to increased pest incidence and tree mortality rates.
- Pacific Decadal Oscillation (PDO)
    - The Pacific Decadal Oscillation is a climatic pattern driven by sea temperatures. It operates on roughly a 60-year period. During the warm phase of the cycle, the Canadian Prairies can expect to experience about 30 dry years. This is followed by 30 wet years during the cool phase of the cycle.
    - In 2008 the PDO flipped from dry years to wet years. Though there are exceptional years, Grand Prairie will experience more wet years than dry during this phase of the oscillation. We are already seeing an increased incidence of fungal pathogens in our urban forest. Monitoring programs have been altered to accommodate this trend.

  - Both deciduous and coniferous trees will benefit from the increased precipitation. Deciduous trees such as elm, ash, maple and oak, which evolved in higher summer precipitation regions, will benefit more than the conifers.
  - Consideration should be given to planting more hardwoods during the wet phase of the Pacific Decadal Oscillation (~ 2008-2038) and more conifers during the dry phase of the PDO (~2039-2069).
- New pest species will arrive in Grande Prairie.
  - City pest control identifies new insect species in Grande Prairie each year. Some of these introduced species will affect our urban forest and may require pest control.
  - It is possible that Dutch elm disease will continue to move westward in Saskatchewan. While there are no native elm stands in western Saskatchewan, proximity to Alberta will increase the risk to Alberta elms from the illegal movement of firewood.
  - Elm bark beetles spread this disease and there are currently no elm beetle populations living in Grande Prairie. The nearest population of these beetles is in Edmonton. However, a warmer climate may allow these beetles to spread to this region and survive.
  - The emerald ash borer (EAB) has killed 150 million ash trees in eastern North America in just 12 years. In Canada, this invasive alien species is found in limited areas of Ontario and Quebec. In the United States, it has reached Colorado.
    - In 2013, EAB moved from Missouri, skipped over Kansas and were found in Colorado. This suggests that infested firewood transportation continues to be an issue despite quarantine regulations.
    - Only Wyoming and Montana separate Alberta from Colorado. Grande Prairie resides on the Alaska Highway. In summer, this highway is busy with RV traffic between Montana and Alaska. Ash trees make up about 20% of street tree population.

INVASIVE ALIEN SPECIES

Purple loosestrife displacing native vegetation, Michigan

Over the 10-year relevance period of this plan:

- As average winter temperatures increase, so does the risk from alien invasive species. An increase in risk is not expected to be noticeable and it will have minimal impact. A disproportionate amount of this increase is expected in the month of March. Therefore, the effect on winter hardiness will be minimal.
- Non-native insect and plant species may spread to this region and be able to survive the warmer winters. These species may attack our urban forest plants and require the City to incur control costs. Several new species are likely to arrive here during the period covered by this plan.
- Some of these new species are likely to be existing regulated pests under the Weed Control Act of Alberta or the Agricultural Pest Act of Alberta. Local landowners, including the City of Grande Prairie, will incur increased control costs. Several prohibited noxious weed species are currently growing within 160 kilometers of Grande Prairie and the risk

that one or more will make its way here is very high. Law requires Prohibited Noxious class weeds, be eliminated, regardless of cost.

- Bio-control agents who were not traditionally hardy in northern Alberta may be trialed in Grande Prairie to control noxious weed species. Were they to become hardy here it would help suppress local thistle populations.
- As our area becomes warmer, there is an increased risk that the mosquitoes that carry West Nile virus could survive here. A 0.5°C rise in average winter temperatures over the next 10 years is likely not enough to allow the *Culex tarsalis* mosquito to spread in our region during the 10-year term covered by this plan.

PEST CONTROL PROGRAMS

Over the 10-year relevance period of this plan:

- Our Mosquito Control Zone Boundaries will grow to encompass an additional 52 square kilometers of control area. This growth is needed to ensure we maintain a control buffer around Grande Prairie as the City grows.
- Some portion or all of the proposed 6316-hectare annexation will occur. This will result in additional mosquito control, weed inspection, and weed control costs (undetermined).
- Several thousand additional trees will have been planted on public lands, requiring additional insect and disease monitoring and control. Detailed tree demographic analysis is scheduled for 2014 based on our new tree inventory.
- Reports of bed bugs and cockroaches are increasing in Grande Prairie. This will result in increased consultation with outside agencies and levels of government.
- City IPM will continue to collaborate with government to monitor invasive alien species.
- Public Education will become a core IPM service. Programs teaching sustainable landscape design and environmentally friendly pest control will reflect changes occurring on public lands. Reliance on social media for low cost information dissemination will increase.
- As the municipal boundaries expand and incorporate wetlands there will be additional conflicts with game birds. City IPM may need to learn new skills managing these animals.
- The Riparian Health Assessment may dictate mandatory Invasive species control operations adjacent to local wetlands.

REGULATORY CHANGES

Over the 10-year relevance period of this plan:

- With the creation of the new Alberta Wetland Policy, it is likely that we will see a tightening of the Special Approvals system for pesticide applications adjacent to Open Bodies of Water. This may increase mechanical operational costs at these sites where pesticides were previously used.
- It is possible that the province will debate whether to enact legislation restricting the cosmetic use of pesticides within Alberta.
- It is possible that local authority will revisit the debate over the need for local bylaws restricting the cosmetic use of pesticides.
- A Tree Protection Bylaw will be drafted.
- The City will likely grow in land area considerably over the next 10 years. The City will be required to inspect these extra lands for regulated weeds and enforce control under the Weed Control Act of Alberta.

PUBLIC OPINIONS TRENDS

Over the 10-year relevance period of this plan:

- Grande Prairie residents continue to be divided concerning the need for pesticide use legislation.
- Residents continue to support City's mosquito control program.
- City IPM will become a primary information resource to local residents fighting pest issues.
- Fewer pesticide options will be available to homeowners for purchase.
- Move away from pest incidence based control operations.
- Move towards pest control that meshes with environmental stewardship.
- Move away from pesticides on residential lands in Grande Prairie.
- Demand for dandelion control in Grande Prairie will continue to decline.
- The public will continue to value street trees highly.
- Older neighbourhoods with established tree canopies will continue to be in demand.
- Customer calls reflect an appreciation for their local environment.

APPENDIX 1: LIST OF RECOMMENDATIONS AND TABLES

APPENDIX 2: URBAN FOREST ANALYSIS

A full analysis of our urban forest would be include these three groups of urban trees:

- Native urban forest communities including upland and riparian habitats — 255 hectares
- Public planted trees — 20,736
- Private planted trees — Unknown

While we know the primary species that make up the Bear Creek Corridor, we do not track statistics regarding species distribution or density, nor what percentage are native or alien species. Likewise, while we understand, in general terms, private landscape species composition, we do not have statistics regarding plant selection or density. Therefore, at this time analysis can only be done on the public tree division of our urban forest.

Analysis is useful to understand the financial and environmental contributions that urban trees provide to our city. This analysis relates primarily to environmental and real estate equity benefits and secondarily to wellness benefits. This analysis does not yield ecosystem service information, as 81% of public trees are alien species, which do not contribute much to these webs.

An adequate understanding of ecosystem services would require a full biological assessments and a trained ecologist.

I-Tree Streets software program 2014 Analysis.

This data was derived by exporting our latest tree inventory data into this analysis program. The I-Tree Streets, northern zone 1 (Montana), was used in the model as the closest comparable area to Alberta conditions. While the results cannot be said to be valid, they can be said to be approximate.

1. Benefit Cost Analysis
    - Annual Energy Benefits of Public Trees from shading and cooling
        - Total savings per year from reduced energy — $113,164
        - Equates to $/tree — $5.46/tree ± 2.02
    - Annual Storm Water Divergence Benefits of Public Trees
        - Total $ saved — $129,149
        - Average $/tree savings — $6.23/tree ± 2.31
    - Annual Air Quality Benefits of Public Trees
        - Total $ saved based on emissions/avoidance — $7,277
        - Average $ per tree — $0.35 ± 0.13
    - Annual CO_2 Benefits of Public Trees
        - Total $ saved — $21,641
        - Average $/tree — $1.04 ± 0.39
    - Stored CO_2 Benefits of Public Trees by Species
        - Stored kilograms CO_2 — 9,239,802

- Total $ saved $152,777
- Average $/tree $10.35

o Annual Aesthetic/Other Benefits of Public Trees by Species

- Total $ value $1,439,264
- Average $/tree $69.41 ± 25.70

o Annual Management Costs of Public Trees

- Total annual management cost of public trees $617,838
- $/tree $29.80
- $/capita $11.03

o Total Annual Benefits, Net Benefits, and Costs for Public Trees

- Total Benefits $1,710,496
- Total Costs $ 617,838
- Net Benefits $1,092,658
- **Benefit – cost ratio** **2.77**

2. Resource Structural Analysis

- Total # of Public Trees 2014 20,736

o Species Distribution of Public Trees (%)

• Colorado Spruce		14.68%
• American Elm		11.85%
• Green Ash		10.44%
• Large Stature Poplars	Most are not native	9.80%
• Black Ash		8.31%
• White Spruce	Native Species	7.87%
• Chokecherry	Native Species in Region	6.68%
• Apple		5.78%
• Other Cherry	Native Species in Region	6.14%
• Other Species	Some native most not	18.45%
• TOTAL		100%

o Size (age) Distribution of Public Tree (%)

- 91% of our public trees are under 30.5cm DBH

o Importance Value for Public Most Abundant Trees

- Total Number of public trees 20,736
- Leaf Area 1,954,912 m^2
- Canopy Cover 500,936 m^2

o Canopy Cover of Public Trees (Hectares)

- Total Land Area 7,532 ha
- Total Street and Sidewalk Area 385 ha
- Total Canopy Cover 50 ha
- Canopy Cover as a % of Total Land Area 0.68%
- Canopy Cover as a % of Total Streets and Sidewalk 13.03%

o Site Demographics

- Front yards 40.49%
- Planting strip 5.83%
- Cut-out .83%
- Median .40%

- Others maintained locations 45.48%
- Other unmaintained locations .46%
- Boulevards 6.51%
- TOTAL 100%

o Land Use demographics

- Single family residential 36.10%
- Multi-family residential 4.40%
- Small commercial 2.48%
- Industrial/Large Commercial 3.58%
- Park/vacant/other 53.44%
- TOTAL 100%

3. Replacement Value

o Replacement Value of Public Trees by Species

- Total Replacement Value of Public Trees $19,937,863

In 2015, tree analysis will use the I-Tree Eco model. This model uses Canadian environmental data sets. When loaded with our tree inventory data it will provide a more precise picture of our urban forests environment benefits.

APPENDIX 3: REFERENCES

PRINT

1. Acorn, John and Sheldon, Iain (2000). Bugs of Alberta. Edmonton: Lone Pine Publishing. p4-150.
2. Bassuk, Nina, Grabosky, Jason, Trowbridge, Peter., Structural Soils A New Medium to Allow Urban Trees to Grow in Pavement. Washington, DC. Library of Congress ISSN: 0195-5764. P1-23.
3. Beiler, Kevin J., Bingham, Marcus A., Deslippe, Julie R., Philip, Leanne J., Simard, suzzanne W., Teste, Francois P., Fungal Biology Reviews Volume 26, Issue 1, April 2012, Mycorrhizal networks: Mechanisms, ecology and modelling. P39-60.
4. Leanne J. Philip, François P. Teste
5. Best, K.F. and Looman, J. (1987). Budd's Flora of the Canadian Prairie Provinces. Hull, QC: Canadian Government publishing Centre. p8-791.
6. Birkeland, Peter W. Soils and Geomorphology, 3rd Edition. New York: Oxford University Press, 1999.
7. Bland, Roger G. and Jacques, H.E. (1978). How to Know the Insects. 3rd ed. Dubuque: Wm. C. Brown Company Publishers. p38-391.
8. Brant, James P., (1994), Forest Insects and Disease Notes, Northwest Region A-027. Natural Resources Canada, p8-10.
9. Carde, ring T. and Resh, Vincent H. (2009). Encyclopedia of Insects. 2nd ed. Burlington, MA: Academic Press. p1-1072.
10. Chaikowsky, C.L.A., (2000). Analysis of Alberta Temperature Observations and Estimates by Global Climate Models. P3.
11. Chesworth, Dordrecht, Netherland: Springer, Edited by Ward (2008), Encyclopedia of soil science, xxiv, ISBN 1-4020-3994-8.
12. Danoff-Burg, James A., Columbia University. The Terrestrial Influence: Geology and Soils.
13. Evenden, M.L., University of Alberta. Biology of Caloptilia fraxinella (Lepidoptera: Gracillariidae) on ornamental green ash, *Fraxinus pennsylvanica* (Oleaceae). p31-39.
14. Fair, Barbara A., Metzger, James D., vent, James. Arboriculture & Urban Forestry 38 (4): July 2012, Characterization of Physical, Gaseous, and Hydrologic Properties of Compacted Subsoils and its effects on Growth and Transpiration of Two Maples Grown Under Greenhouse Conditions. P151-159.
15. Facciola, Stephen (1990). Cornucopia a Source Book of Edible Plants. Vista: Kampong Publications. piii-v.
16. Friedman, David, Montana, Carl, Lamm, David, Smith, Chris,. Impact of Soil Disturbance During Construction on Bulk Density and Infiltration in Ocean County, New Jersey, NJ. 2001. P1-17.
17. Gray, Peter (1967). The Dictionary of the Biological Sciences. 2nd ed. New York: Reinhold Publishing. 366.
18. Harper, A.M. and Melvin, J.C.E. and Wong, H.R. (1977). Common Insect and Mite Galls of the Canadian Prairies. Edmonton: Canadian Forestry Service. p1-74.
19. Hartnett, David C., Kobberman, Kerri, smith, Melinda D., Wilson, Gail W.T., 2001. American Journal of Botany, Effects of mycorrhizae on growth and demography of tallgrass prairie forbs.
20. Henderson, Norm and Sauchyn, Dave, Prairie Adaptation research Collaborative, Climate Change Impacts on Canada's Prairie Provinces: A Summary of our State of Knowledge, 2007. p3-15.
21. Hobbs, Elizabeth R. Macalester College. Species Richness of Urban Forest Patches and Implications for Urban Landscape Diversity. 1988. Landscape Ecology vol. 1 no.3 p 141-152.
22. Industrial Vegetation Management Association of Alberta (2008). Industry Standards and Good Practices for Vegetation Management. 5th ed. Vancouver, BC: Joyce Authur, technical Communications. p1/1-7/36.

23. International Society of Arboriculture (1997). Plant Health Care for Woody Ornamentals. Champaign, IL: Printec Press. p1-197.
24. Ives, W.G.H. and Wong, H.R. (1988). Tree and Shrub Insects of the Prairie Provinces. Edmonton: Canadian Forestry Service. p5-239.
25. Johnson, Norman F. and Triplehorn, Charles A. (2005). Borror and Delong's Introduction to the Study of Insects. 7th ed. United States: Peter Marshall. p1-777.
26. Johnson, Warren T. and Lyon, Howard H. and Sinclair, Wayne A. (1987). Diseases of Trees and Shrubs. China: Cornell University Press. p12-507.
27. Johnson, Warren T. and Lyon, Howard H. (1991). Insects that Feed on Trees and Shrubs. 2nd ed. Hong Kong: Cornell University Press. p16-502.
28. Knowles, Hugh (1989). Woody Ornamentals for the Prairies. Edmonton: University of Alberta Printing Services. p85-279.
29. Leopold, Aldo, 1948. A Sand County Almanac, Land Ethic. P 1-240.
30. MacLellan, C.R. (1978). Field Evaluation of Synthetic Sex Pheromone Attractants for the Eye Spotted Bud Moth (Lepidoptera: Olethreutidae) and three Leaf roller Species (Lepidoptera: Tortricidae). The Canadian Entomologist, 110, p 847-852 doi:10.4039/Ent11085-1
31. McGinn, S.M. (2010). Weather and Climate Patterns in Canada's Prairie Grasslands. In Arthropods of Canadian grasslands (volume 1): Ecology and Interactions in Grasslands Habitats. Edited by J.D. Shorthouse and K.D. Floate. Biological Survey of Canada. p105-119.
32. Mengersen, Ernest and Philip, Hugh (1989). Insect Pests of the Prairies. Edmonton: University of Alberta Printing Services. p5-107.
33. Quarles, William (2012). The IPM Practitioner Monitoring the Field of Pest Management. Berkeley, CA: Bio-Integral Resource Center. p1-41.
34. Quarles, William (2012). The IPM Practitioner Monitoring the Field of Pest Management. Berkeley, CA. Volume XXXIII. p8.
35. Stein, Sara (1993). Noah's Garden. New York. Houghton Mifflin Company. p154-172.
36. Tallamy, Douglas W. (2007). Bring Nature Home. 7th ed. 2013. USA. p11-65, 107-120.
37. Urban, James (2008). Up by Roots Healthy Soils and Trees in the Built Environment. Wichita, KS: ADR Book print. p1-453.
38. Voroney, R. P., 2006. The Soil Habitat in Soil Microbiology, Ecology and Biochemistry, Eldor A. Paul ed. ISBN=0-12-546807-5
39. Wilkinson, Kathleen (1990). Trees and Shrubs of Alberta. Edmonton: Lone Pine Publishing. p9-183.

ELECTRONIC

40. Alberta Biodiversity Monitoring Institute 2012, Biodiversity Browser, viewed 06/03/2012, http://www.abmi.ca/abmi/biodiversitybrowser/species.jsp
41. Alberta Sustainable Resources Development 2011, 31/03/2011, general Status of Alberta Species 2010, viewed 06/03/2012, http://www.srd.alberta.ca/FishWildlife/SpeciesAtRisk/GeneralStatusOfAlbertaWildSpecies/GeneralStatusofAlbertaWildSpecies2010/Default.aspx
42. BC Ministry of Agriculture 2012, Fire Blight of Apple and Pear, viewed 03/28/2012, http://www.agf.gov.bc.ca/cropprot/tfipm/fireblyt.htm
43. Blenis, P.V., Knowles, N.R., Tompkins, D.K., Ross, J.B. 1994, Fairy Ring Control with Surfactant using High Pressure Injection, Prairie Turfgrass Research Institute Olds College, viewed 03/28/2012, http://www.oldscollege.ca/ptrc/1997_ar/9406.html

44. Broemsen, Sharon L., Jacobs, Janette L. 2012, Diseases of Landscape Ornamentals, viewed 01/09/2012, http://cipm.ncsu.edu/ent/southern_region/ripm/chap4/opm/chap4.htm
45. Card, Adrian, Reeder, Jean Ph.D., Whiting, David, Wilson, Carl. Tree Heat Stress Symptoms, viewed 02/13/2012, http://warnell.forestry.uga.edu/service/library/index.php3?docID=195&docHistory%5B%5D=12 CSU Extension, Compaction Around Trees, http://www.ext.colostate.edu/mg/gardennotes/215.html#excessive
46. City of Airdrie 2001, Integrated Pest Management Plan, viewed 02/13/2012, http://www.airdrie.ca/
47. City of Calgary 1998, Integrated Pest Management Plan, viewed 02/13/2012, http://www.calgary.ca/CA/city-clerks/Documents/Council-policy-library/csps017.pdf?noredirect=1
48. City of Edmonton 2012, Dothiorella Elm Wilt, viewed 02/13/2012, http://www.edmonton.ca/for_residents/pest_management/dothiorella-elm-wilt.aspx
49. City of St. Albert 2011, Integrated Pest Management Plan, viewed 02/13/2012, http://stalbert.ca/uploads/files/our_government/administration/public_works/New%20Pages%202011/City%20of%20St.%20Albert%20IPM%20June%202011.pdf
50. Convention on Biological Diversity, Ecosystem Approach, viewed 06/03/2012, http://www.cbd.int/ecosystem/description.shtml
51. Cree, L, Pucat, A.M., Favrin, R. 2003, Japanese Apple Rust, Canadian Food Inspection Agency science Branch, viewed 02/13/2012, http://www.inspection.gc.ca/english/plaveg/protect/listpespare.shtml
52. Cuperus, Gerrit, 2004, Ornamental Pest Management, University of Oklahoma, viewed 03/28/2012, http://cipm.ncsu.edu/ent/southern_region/ripm/chap4/opm/opm.htm
53. Dinelli, D. (1999). IPM Leading to Holistic Plant Health Care for Turfgrass: A Practitioner's Perspective. In: Radcliffe (Eds.), Radcliffe's IPM World Textbook. University of Minnesota, St. Paul, MN. Retrieved September 15, 2008, http://www.ipmworld.umn.edu/
54. Earth Trends the Environmental Information Portal, Staff of World Resources Program and Amy Wagener 2001, World Resources 1998-99, Bioinvasions: stemming the Tide of Exotic Species, viewed 06/03/2012, http://earthtrends.wri.org/features/view_feature.php?theme=7&fid=18
55. Environment Canada, Climate Trends and Variations Bulletin, Winter Summary 2011-2012., http://www.ec.gc.ca/adsc-cmda/default.asp?lang=en&n=8C03D32A-1
56. Environment Canada, Climate Trends and Variations Bulletin - Summer 2011. http://www.ec.gc.ca/adsc-cmda/default.asp?lang=En&n=30EDCA67-1
57. Food and Agriculture Organization of the United Nations, February 1998, SD Dimensions, Crop Genetic Resources, viewed 27/03/2012, http://www.fao.org/sd/EPdirect/EPre0040.htm
58. Frey, Ken (2014). Integrated Environmental Plant Management Association Conference, Managing Common Pests in the Landscape: An Ecological Perspective, viewed 30/01/2014.
59. Griswold , Terry, Packer, Laurence, Ratti, Claudia, Sheffield, Cory S., Canadian Journal of Arthropod Identification, Leafcutter and Mason Bees of the Genus Megachile Latreille (Hymenoptera: Megachilidae) in Canada and Alaska1, CJAI 18 November 29, 2011, viewed 03/26/2012, http://www.biology.ualberta.ca/bsc/ejournal/srpg_18/introduction.html
60. Guardian, The, 2010, Juliette Jowit, Scientists prune list of world's plants, viewed 06/03/2012, http://www.guardian.co.uk/science/2010/sep/19/scientists-prune-world-plant-list
61. Manitoba Agriculture, Food and Rural Initiatives 2006, Bronze Leaf Disease of Poplar, viewed 02/13/2012, http://www.gov.mb.ca/agriculture/crops/diseases/fac56s00.html http://www.gov.mb.ca/agriculture/crops/insects/fad84s00.html

62. Ministry of Agriculture, Government of British Columbia 2012, Tree Fruit Insects and Diseases, viewed 01/13/2012, http://www.agf.gov.bc.ca/cropprot/tfipm/treefruitipm.htm
63. Ministry of Agriculture, Government of British Columbia 2012, Tree Fruit Insects and Diseases, viewed 01/13/2012, http://www.agf.gov.bc.ca/cropprot/tfipm/treefruitipm.htm
64. Tallamy, Doug, Dr. (2011),"Networks for Life, Addressing the Biodiversity Crisis through Landscape Connectivity". Viewed November 18, 2013, http://www.youtube.com/watch?v=soOBCVD6ZWI
65. United States Department of Agriculture, National Agricultural Library 2009, National Invasive Species Information Center, Viewed 06/03/2012, http://www.invasivespeciesinfo.gov/council/intro.shtml
66. Weicherding, Patrick, Ten Tree Diseases Every Tree Care Provider Should Know 2012, University of Minnesota, St. Paul, MN, viewed 03/28/2012, http://www.powershow.com/view/273a7a-NDFmN/Ten_Tree_Diseases_Every_Tree_Care_Provider_Should_Know_flash_ppt_presentation
67. Whiting, David , IPM: Plant Health Care, Colorado State University Extension 2011, Department of Horticulture, Colorado State University, viewed 08/02/2012, http://www.cmg.colostate.edu/gardennotes/101.pdf
68. Wolfe, Kathleen. PH.D, Greening Cities: Good Health, Crime & Fear a literature review, Urban Forestry/Urban Greening Research, June 2010, http://depts.washington.edu/hhwb/Thm_Crime.html

General knowledge information and definitions were obtained from many general knowledge sites, including Wikipedia, Wiki Answers, and Free Dictionary, and verified by alternative sources.

APPENDIX 4: GLOSSARY OF TERMS

A

Abiotic - Non-Living

Acute - Short term

Allelopathy - a biological phenomenon by which an organism produces one or more biochemicals that influence the growth, survival, and reproduction of other organisms.

Alien - An organism, especially a plant or animal that occurs in or is naturalized in a region to which it is not native.

B

Biota - The animal and plant life of a particular region, habitat, or geological period.

Biotic - Living

Biological Control - The use of living organisms to reduce or maintain pest populations at a tolerable level

Bio-rational - Pesticides derived from a variety of biological sources including bacteria, viruses, fungi as well as chemical analogues of naturally occurring biochemicals such as pheromones and insect growth regulators.

Bulk Density - the ratio of dry soil mass to bulk soil volume (including pore spaces)

C

Cambium - A cellular plant tissue from which phloem, xylem, or cork grows by division, resulting in annual growth rings in woody plants in and secondary thickening of herbaceous plants.

Cation – a positively charged ion held in a soil solution

Chemical Control - The use of a control product such as a pesticide to suppress or control a pest

Chronic - Long term

Community - A group of populations of plants and animals in a given area.

Control – To inhibit the growth or spread or to destroy (Weed Control Act of Alberta).

Control Product - Any product, device, organism, substance, or thing that is manufactured, represented, sold or used as a means for directly or indirectly controlling, preventing, destroying, mitigating, attracting, or repelling any pest

Cultural Practices - Management practices that focus on the prevention of pest by maintaining healthy hosts through proper selection, planting, pruning, mulching and sanitation procedures.

D

Deflocculation – Occurs in soils where exchangeable sodium reverses the process of soil particle aggregation. This causes the soil aggregates to disperse into their constituent individual soil particles. Without the formation of soil aggregates, air channels are smaller resulting in reduced aeration and drainage.

Denitrification - An anaerobic microbial facilitated process of dissimilatory nitrate reduction that may ultimately produce molecular nitrogen (N2) through a series of intermediate gaseous nitrogen oxide products.

Destroy – To kill all growing parts or to render reproductive mechanisms non-viable (Weed Control Act of Alberta).

Diversity – The variety of species, vegetation communities, habitats, or landforms in a given area.

E

Ecology - The study of relationships between living things, with each other and with environments.

Ecological Approach - A systems approach to prevention and management where control strategies are determined based on the relationship between the target organism's life cycle and its environment.

Ecosystem - A community of organisms and their physical environment.

Endemic - Those species of plants and animals, which are found exclusively in a particular area. They are naturally not found anywhere else.

Environmentally Sustainable - IPM practices that provide the desired result of reducing the impact of pest populations, while ensuring that impacts to the general environment are minimal, both initially and in the long term. Sustainability is the long-term maintenance of responsibility, which has environmental, economic, and social dimensions, and encompasses the concept of stewardship.

Evaluation - Involves the analysis of treatment events or strategies to help determine the effectiveness of the control program.

Extirpation – A species which ceases to exist in a geographic area, though it still exists elsewhere.

Exudates – Substances that ooze out from plant pores.

F

Flocculation – the combining of charged soil particles caused by ionic attraction with cations.

Fungicide – A chemical substance or cultural biological organism used to kill or suppress/prevent the development of fungi.

G

Girdle – The act of severing the cambium layer of a woody plant stem.

Green Infrastructure – A concept that highlights the importance of the natural environment in decisions about land-use planning. There is an emphasis on the ecological service functions provided by a network of natural ecosystems, with an emphasis on interconnectivity to support long-term sustainability. Native, naturalized and amenity trees are examples of green infrastructure.

H

Herbicide – A chemical substance or cultural biological organism used to kill or suppress the growth of plants.

Husbandry – The agricultural practice of breeding and raising animals.

I

Indigenous – Originating and living or occurring naturally in an area or environment

Insecticide – A chemical substance or cultured biological organism used to kill or suppress the growth of insects.

Integrated Pest Management (IPM) – A decision based pest management system that utilizes all suitable techniques to reduce pest populations to tolerable levels while maintaining environmental sustainability.

IPM Programs – Pest control programs created to manage individual pest populations at acceptable levels.

Interaction – Occurs as two or more objects have an effect upon one another.

Injury Levels – The point in growth of vegetation or a pest problem where it will cause an unacceptable impact on: public safety, recreation, health, natural and/or managed ecosystems; aesthetic values; economic injury to desirable plants, or the integrity, function, or service life of facilities.

Invasive - A tendency to intrude, encroach and spread.

Invasive Alien Species - Species whose introduction and/or spread outside their natural past or present distribution threaten biological diversity.

Invertebrate – Animals without a backbone (spinal column).

Ion - A molecule with a positive (+) or negative (-) charge.

J

K

L

Leaf - An organ of a vascular plant.

Leaflet - A part of a compound leaf. A leaflet may resemble an entire leaf, but it is not borne on a stem as a leaf is, but rather on a vein of the whole leaf.

M

Management - To direct, to a degree, the outcome of a particular project or land area.

Material Safety Data Sheet (MSDS) - a listing of chemical, technical and hazard information for the specific product it names. It states health hazards of product use and a list of all hazardous ingredients (unless a specific exemption has been granted). The sheet details safe handling and usage procedures for all applications.

Matrix - A situation or surrounding substance within which something else originates, develops, or is contained.

Miticide - A chemical substance used to kill or suppress the growth of mites.

Monitoring - The regular surveying of sites and/or features to understand and identify the location and extent of potential pest management problems.

Mycorrhizae - A symbiotic association between a fungus and the roots of a vascular plant.

N

Native - Species of animals or plants that have not been introduced by people or their direct activities. Native species may be native to more than one location.

Naturalized – The establishment of an organism that lives wild in a region where it is not indigenous.

Noxious Weeds – Plant species regulated under the Weed Control Act of Alberta 2010 as Noxious Weed species. These plants have the potential to out-compete field crops and riparian plants and therefore pose a major risk to agriculture and native habitats. Control of these plant species is required by law.

Non-Target Organism - Any organism affected by a pest control operation other than the intended target. These effects are deemed non-target effects.

O

Organism - Any contiguous living system such as an animal, fungus, microorganism, or plant.

P

Paradigm - A worldview underlying the theories and methodology of a particular scientific subject.

Paradigm Shift – The shift from one set of underpinning concepts to another. The new paradigm is not built on the old but on new concepts.

Parasite - An organism that has a deleterious symbiotic relationship with another organism or host species without directly killing the host species.

Parasitoid - An organism that spends a significant portion of its life history attached to or within a single host organism in a relationship that is in essence parasitic. Unlike a true parasite, however, it ultimately sterilises or kills, and sometimes consumes, the host.

Park - An area of publicly owned land established for the benefit of residents and visitors. Park spaces may encompass both passive and active utilities in beautified settings.

Pathogen – A microorganism such as a virus, bacterium, prion, or fungus that causes disease in its animal or plant host. The influenza virus is a common pathogen.

Pest - An organism with characteristics that people see as damaging or unwanted. The key component of this definition is that people dictate what is labelled a pest. A pest is a time and site-specific concept.

Pesticide - Any product, device, organism, substance or thing that is manufactured, represented, sold or used as a means for directly or indirectly controlling, preventing, destroying, mitigating, attracting or repelling any pest.

Pest Control Products Act (Canada) - A Federal Act administered by Health Canada. The Act and Regulations cover the following areas: registration, labeling, classification, import/export control, storage, packaging, advertising, display, distribution, and use. All pesticides used in Canada must be registered under the Pest Control Products Act.

Plant Health Care (PHC) - A proactive management process that stresses maintaining plant health in order to reduce the occurrence of pests, disease and disorders. Therefore, the plant and its requirements become the central focus of activities.

Preventative Measures – Proactive management practices taken to prevent or minimize pest establishment

Primary Pest – Pests that are capable of successfully attacking and breeding in previously undamaged hosts. Primary pests may weaken hosts enough for secondary pests to become established.

Proctor Density Test - A laboratory method of experimentally determining the optimal moisture content at which a given soil type will become most dense and achieve its maximum dry density. Proctor densities are used to relay engineering standards needed to support construction works.

Prohibited Noxious Weeds – Plant species regulated under the Weed Control Act of Alberta 2010 as Prohibited Noxious Weed species. Eradication of these plant species when found is required by law.

Public Education – The act of educating the public concerning pest management issues and the knowledge and development arising from this training.

Q

R

Rational – Consistent with or based on reason. Logic chain or explanation based on reasoning.

Record-keeping - Maintenance of written records of specific pest management factors observed during monitoring, information on labour and materials used in implementation of the urban IPM program, results of applied pest management strategies and comprehensive data on pesticide applications.

Respiration - the physiological process that enables animals to exchange carbon dioxide, the primary product of cellular respiration, for oxygen.

Rhizosphere - the region of soil in the vicinity of plant roots in which the chemistry and microbiology is influenced by their growth, respiration, and nutrient exchange.

Rodenticide - A chemical substance that kills rodents.

S

Secondary Pest – A pest that under normal conditions is not a problem but becomes serious following a disruption of control by a natural enemy and/or the weakening of a host plant due to primary stressors.

Semiochemical - A generic term for a chemical substance or mixture that carries a message. These chemicals act as messengers within or between species. It is usually used in the field of chemical ecology to encompass pheromones, allomones, kairomones, attractants and repellents.

Soil Food Web - The community of organisms living all or part of their lives in the soil. It describes a complex living system in the soil and how it interacts with the environment, plants, and animals.

Special-Use Approval - An approval issued by Alberta Environmental Protection for projects in specific locations. This includes pesticides that are excluded from the Environmental Code of Practices for Pesticides but used within 30 horizontal metres of open bodies of water.

Species - A fundamental category of taxonomic classification, ranking below a genus or subgenus and consisting of related organisms capable of interbreeding and creating fertile offspring.

Stressor - An agent, condition, or other stimulus that causes stress to an organism.

Statistically Significant - A result that is unlikely to have occurred by chance.

Structural Root Zone (SRZ) – The large woody roots attached the root flare that provide structural support to the tree.

Suppress - Prevent the development, action, or expression of something.

T

Timing – Involves the ability to select the precise moment for doing something for optimal effect.

Transportation of Dangerous Goods (TDG) - An international system of identification so that dangerous goods may be handled, stored and shipped safely. This is enforced by a Federal Act. It applies to all persons who handle or offer dangerous goods for transport (i.e. shipper, mover, and receiver).

Tree Decline – The chronic malfunction and deterioration of a tree's bio-chemical process leading to death of trees or a stands of tree. Trees may decline because of predisposing factors such as borderline hardiness or inadequate soil volume or because of primary stressors such as insect defoliation or contamination from pollutants such as road salt.

Tree Protection Zone (TPZ) – The rooting area around at tree where root damage is especially injurious to the tree.

Trophic Level - of an organism is the position it occupies in a food chain. The number of steps an organism is from the start of the chain is a measure of its trophic level. Plants form the lowest trophic level and *Homo sapiens*, the highest trophic level.

U

Underpinning - A set of ideas, motives, or devices that justify or form the basis for something.

Undeveloped Land - Land that does not contain any permanent buildings, structures or facilities.

Urban Forest - A collection of trees that grow within a city, town or a suburb. In a wider sense, it may include any kind of woody plant vegetation growing in and around human settlements.

Urban Forestry - An integrated, citywide approach to the planting, care and management of trees in the city to secure multiple environmental and social benefits for urban dwellers.

USDA – United States Department of Agriculture.

V

Vascular Plant - a plant that has conducting tissue for the movement of water, sugars and nutrients throughout the plant.

Vector - An insect or other organism that transmits a pathogenic fungus, virus or bacterium.

Vertebrate – Animals that have a backbone (spinal column).

W

Weed - A wild plant growing where it is not wanted and/or in competition with cultivated plants.

Weed Control Act - A provincial Act intended to protect agricultural and riparian land from invasive plants.

Workplace Hazardous Materials Information System (WHMIS) - Canada's national hazard communication standard utilizing cautionary labelling, material safety data sheets and worker education programs.

X

Y

Z