Introduction

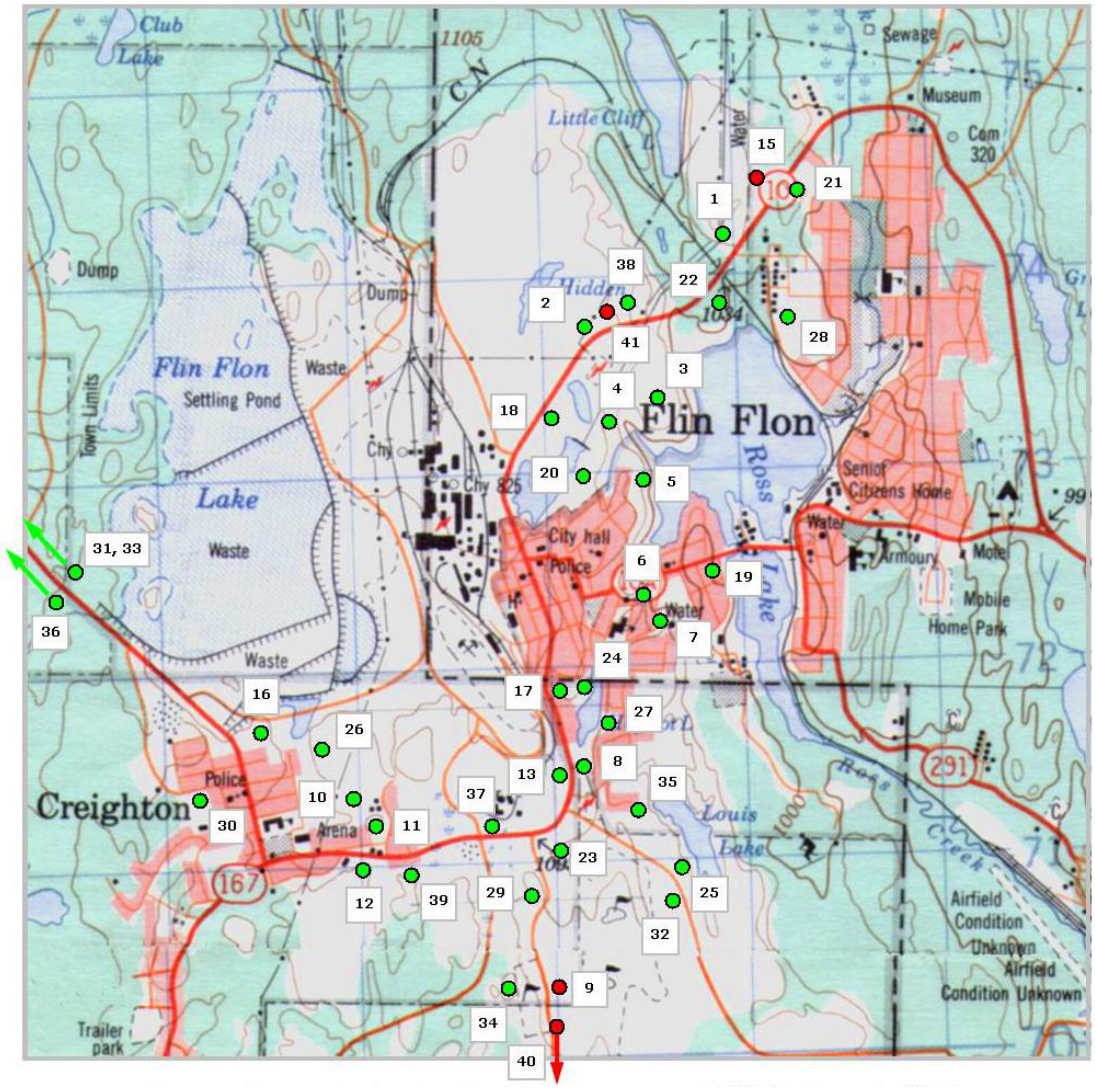
- 2014 was the fifteenth year for our community-based project.
- Our purpose is to accelerate the re-vegetation of barren areas in and around our communities by the application of crushed limestone.
- Because of the ruggedness of our terrain, it is not feasible to do the work by machine, so we use people-power, namely students from local schools and adult volunteers.
- The winter of 2013/2014 was cold with above normal snow accumulations – and spring arrived late. The summer was in general cool and wet – with brief warm spells. There were light overnight frosts in early September and some milder days later in the month. Moderate snow falls started late October – with accumulations to around 40-45cm by year end.
- The organizational and scientific backgrounds to our project are explained in Appendices 1 and 2.

Our Partners

We gratefully acknowledge that our project has been made possible through the generosity of our partners. Funding for the work in 2014 came from Hudbay Minerals Inc. (HMI). Flin Flon School Division and its Youth Mentor program and Creighton School Division supplied the bulk of our workforce. Edgar Wright helped us with plant identification.

Areas Treated

In the map below, green circles indicate areas we treated in 2000 through 2013, red circles indicate those treated in 2014. Area names are as follows: 1: Balsam, 2: Rock Cut, 3: Second Valley North, 4: Second Valley West, 5: First Avenue, 6: Hiawatha, 7: Grandview, 8: Hapnot, 9: Phantom, 10: Knight North, 11: Knight, 12: Pizza, 13: South Main, 15: Esso, 16: Creighton North, 17: Super K, 18: Triple Seven, 19: Market, 20: Reservoir Hill, 21: Lancaster, 22: Railroad, 23: Phantom North, 24: Hapnot North, 25: Louis, 26: Creighton East, 27: South Hudson, 28: Roche, 29: Phantom Northwest, 30: Red Mountain, 31: Hilary, 32: Golf, 33: Sand Bar, 34: Driving Range, 35: Icehouse, 36: Creighton Creek, 37: Headframe, 38: Rock Cut North, 39: Larson, 40: Soccer, 41: Rock Cut Middle.



During a field season lasting from May 26 through August 14, we spread 31.7 yards of crushed limestone (dolostone) in four areas to cover a total of 1.56 hectares (3.85 acres). During the project period 2000-2014, we have treated 55.5 hectares (137.14 acres) with 1,194.0 yards of limestone (an application rate of 21.5 yards/hectare).

Volunteer Field Personnel

The work was carried out by 548 individuals during 26 sessions. This number includes 507 Flin Flon and Creighton school students in 23 sessions in June. One session was handled by a group of 17 participants in the City of Flin Flon Recreation Department's 'Summer in the Parks' program in July, and two sessions involved 24 participants from the Flin Flon Community Youth Resources Centre in August. Details on personnel distribution are summarized in Appendix 3. Below we see students taking 'Freezie' breaks at their work areas. At left is a McIsaac grade 2/3 group at the Esso area. At right are McIsaac grade 2s at the Phantom area.

New Growth in Treated Areas

The areas we are treating are either totally barren, or have a few scattered tufts of the acid- and metal-tolerant grass Agrostis stolonifera, and a few stunted relict poplars, birches, and willows. Original organic topsoil is commonly entirely absent, or where present is thin. The ground surface is a combination of bare rock outcrop, and sandy or silty gravel with a variable content of pebbles and boulders. Areas treated in May and early June of each project year have generally shown some signs of life (typically Manitoba maple) within a month. By August, seedlings of birch, aspen, balsam poplar, and a variety of willows appear. Although the maples tend not to over-winter well, the others

flourish, and in the second season grow to about half a metre. Conifer seedlings tend not to appear until a year or two after the treatment.

As of fall 2014, deciduous trees were more than 2 metres high in 31 of our treated areas, 4 or more metres high in 18 areas, 5 or more metres high in 8 areas, and 6 metres high in 5 areas (Creighton East, Hapnot, Pizza, Knight and Knight North). Our tallest self-seeded conifers are at the Hapnot, Phantom, Knight and Knight North areas. The tallest jack pines – commonly associated with old relict parents – are 5 or more metres high at the Knight and Knight North areas. Our tallest spruce – at the Hapnot area – is 4 metres high.

Until 2009, self-seeded tamarack (three individuals) had been noted only at our Knight area - the tallest is now 3.5 metres high. A small tamarack seedling first noted at our Creighton East area in 2010 is doing well – a second was noted close by. The tamaracks noted for the first time at two locations in our Pizza area in 2013 are also doing well. Individual Scots pines were noted for the first time at the Knight and Knight North areas in 2010 – another was noted in the Creighton East area in 2013. These were presumably seeded from imported trees planted in local yards. The individuals at the Knight North and Knight areas are now 4.5 and just over 4 metres high respectively. Alders were not seen in any of our areas until 2005 – they have now been noted in 18 - and are particularly numerous at the Sand Bar area. In 5 of these areas, it appears that the seed came from individual alders put in at our 'plantations' in 2001 – see 'Planting and Seeding' below. Individuals and small clusters of dwarf birch are present at our Knight, Phantom, Creighton East and Sand Bar areas. At left below is a view looking north at our Knight area showing a dense growth of birch – individuals in the field of view are 4-6 metres high. The view at right shows one of the tamaracks at our Pizza area.

Although understory species such as fireweed, rough cinquefoil, raspberry and bearberry are quite widespread, they tend in general to be few and far between. Until now, our best areas in terms of variety and density of understory species have been South Hudson and Roche. In 2013 it was noted that an even greater variety and density of these species have become established at the Headframe area. The seed for these is clearly derived from immediately adjacent areas that were landscaped by HMI a few years ago. It is of interest to note that there is a greater variety and number of understory species coming through in areas we treated at our Louis and Esso areas in 2010 than in adjoining areas that were treated in earlier years. The grass A. stolonifera tends to spread following treatment, and a few other grass and sedge species have appeared in some areas. Some of our best areas in terms of density of woody species – such as Creighton North - still have almost no understory vegetation.

For the past several years, carpets of dead leaves have been accumulating in some of our most densely vegetated areas. These constitute the beginnings of a new organic topsoil. The mushroom Amanita muscaria was first noted in one of these shady and leaf-carpeted spots at our Knight North area in 2010. In 2013, Amanita was noted in similar situations in six of our areas – but this year only two Amanita individuals were noted – at our Creighton North area. Our only other mushroom, the red-brown Laccaria laccata, is very common and has been noted at most of our areas since the early days – though this year they have been less numerous than usual.

We have recognized since the early years of the project that some areas are 'slower' than others, that is, there is a variation in the rate of germination and growth and in vegetation density from one area to another. We hope that studies presently underway – see 'Scientific Studies' below - will provide an explanation and a remedy for this. The map - appendix 4 - provides an indication as to how well each individual area is progressing. Parameters used in constructing the map are: density of woody species, height of woody species, number of under-story species present, and presence or absence of self-seeded conifers. It is notable that the four areas characterized as 'poorest' are within about a kilometer of the HMI stack. The six areas characterized as 'best', are all south and southwest from Flin Flon.

Planting and Seeding

Although we depend primarily on the natural 'seed rain' to do the re-vegetating for us, we have done some small-scale experimental planting and seeding.

In September 2001, following advice from our consultant the late Professor Winterhalder, small 'plantations' were established in ten of the areas we had previously treated. In most we put in four spruce seedlings, one alder (a nitrogen fixer) and one pine or tamarack. These were taken from the right-of-way along the Kisseynew Lake road during a very wet spell. To date, survival in the plantations has been very good. A grass fire in June 2010, which reached the west end of the Balsam plantation, killed the pine and the alder and singed one of the spruce. In 2012, five pine seedlings were noted in the immediate vicinity of the burned pine – presumably derived from its cones. All were doing well in 2014. Vandals broke off the main trunks of the two pines at the Hapnot plantation at knee-height in 2010, but growth of the lower branches continues – the tallest is now 2.6 metres high. It is of interest to note that growth and state of health in the plantations varies from area to area, and closely parallels the variation in area 'vegetation-cover status' (see appendix 4). Plantation conifers in some areas categorized as 'best' (such as Knight and Knight North) are very healthy and 4 to a little over 5 metres high, while those our 'poor' areas (such as Rock Cut and First Avenue) are more sickly-looking and are not a great deal taller that when they were first put in. Pines at the Balsam and Knight plantations produced cones for the first time in 2008. All our plantation pines now have cones. The tallest spruce in our Knight North plantation produced masses of cones in 2009 – these were the first spruce cones to have appeared in any of our treated areas. In 2014, cones were noted on spruce at six plantations.

Pine and spruce cones were scattered in seventeen of our areas in 2002 through 2004. Germination has taken place in fourteen of these areas. Some of the pine seedlings from cones scattered by Saskatchewan Ministry of Environment personnel at our Knight North area in February 2002 are now 5-6 metres high. Pine seedlings in the other areas are up to 4 metres high. A spruce at our Second Valley area is 1.6 metres high. The pines at the Knight North area produced cones for the first time in 2008. Since then, cones have appeared on pines at nine other areas.

In 2003, 2005-2007, 2012 and 2013, local Cubs and Beavers planted hundreds of pine and spruce seedlings – as well as several other species – at the Second Valley, Reservoir Hill, Phantom, Balsam/Esso, Phantom North and Driving Range areas. Survival rate for the conifers has been high – probably better than 90% in most areas. Pines in some areas are now 2.2-2.3 metres high. Since 2010, some have produced cones. Spruce are up to 1.3-1.7 metres high. In 2013, spruce cones appeared for the first time at the Balsam and Second Valley areas. Results at Second Valley are patchy - mortality for both spruce and pines is high at square 1, but healthy spruce up to 1.4 metres high are quite widespread at

squares 5, 6 and 8. It is no longer possible to distinguish the Cub and Beaver spruce and pines from the many self-seeded conifers that are coming through in the Phantom area.

Spruce seedlings from SaskPower's Shand Greenhouse were supplied to us by Saskatchewan Ministry of Environment Creighton office personnel in 2005. They were put in by Green Project staff at three of our areas. Those at our Balsam and Railroad areas and are doing quite well and are up to 1.65 metres high. Some are healthily green and filling out (particularly at Balsam), while others are smaller, thinner and less regular, and tend to be a bit yellowish. Those put in at the Triple Seven area were buried during HMI landscaping activities in the fall of 2008.

In April 2009, Donna Lundquist of the Saskatchewan Ministry of Environment donated 14 kilograms of jack pine and white spruce seeds. These had been collected in 1995 and 1978 respectively, and were being removed from inventory because of their low (estimated 40%) viability. They were scattered in six of our areas by Green Project staff on April 25, 2009 and by Creighton grade 4 students at the Sandbar area June 8, 2009. Seedlings have come through in all of the areas. Pines at the Railroad and Hilary areas are now up to 1.3 and 1.8 metres high respectively. Pine cones were noted for the first time in 2013 in four of the areas – and in a fifth in 2014. Spruce are generally smaller and sparser – and so far lack cones.

Supplementary documentation on the above, and on some of our other planting and seeding projects is available on request, and will shortly be posted on our web site.

Scientific Studies

As noted above, many of our areas have responded very well to the limestone treatment, others are coming along more slowly, while in a few the response has been minimal. What accounts for this varying response? Might it be due to variations in the base-metal content of the soil? What treatment in addition to the application of crushed limestone might be needed to enhance germination and growth of woody species in our 'slow' and 'poor' areas – and to encourage growth of understory species?

Our consultant Professor Keith Winterhalder made brief visits to Flin Flon in the summers of 2000 through 2003. He monitored vegetation growth and pH changes in the soil in areas we had treated – he also checked up on experimental plots he had established south of Creighton in 1994 and 1997. He submitted reports on his findings to the Green Project and to HMI in 2001 through 2004. At the time of his death in

October 2005, he had been conducting greenhouse experiments on mixtures of Flin Flon soils with other additives. Manitoba Conservation ecosystem monitoring specialist Geoff Jones visited Flin Flon in 2008 to resume monitoring vegetation on the transect lines set up by Professor Winterhalder. A detailed report on this work was submitted in June, 2009. A further five days of field work was carried out in July, 2009. We were saddened to learn that Geoff passed away in January, 2010.

Following preliminary discussions with HMI and Green Project coordinators in late 2007, members of the faculty at the University of Saskatchewan's Department of Soil Science drafted a proposal for a multi-year research project aimed at significantly expanding on the work initiated by Professor Winterhalder. Funding for a five-year project was secured from HMI and the Natural Sciences and Engineering Research Council of Canada (NSERC).

In December 2013, Green Project and HMI personnel were briefed by faculty and students at the Saskatoon campus on aspects of their project. While earlier broad-scale studies had shown that anomalous metal contents in soils fell off to background levels at distances up to around 100 kilometres from the smelter, the present study shows that metal values within 5 kilometres are extremely patchy and variable and seem to depend more on factors such as local topography and soil character than on distance from the source.

A number of metals have been have been analysed for - with zinc and copper values found to range up to around 15,700 and 12,800 parts per million respectively. Metal speciation studies have been carried out at the Canadian Light Source synchrotron facility on campus – concentrating on zinc, which has been recognized as a key factor in limiting natural revegetation. Samples studied include a variety of untreated Flin Flon area soils. Studies were also carried out on changes in metal speciation following the addition of crushed limestone and a variety of other amendments.

Planting and seeding experiments were carried out in the field as well as in growth chambers on campus. A variety of amendments such as smectite, meat and bone-meal biochar and municipal compost were tried – in addition to the crushed limestone and fertilizer. The general conclusion is that any treatment adopted will depend on local topography and soil conditions – and that these and other parameters need to be characterized in detail before embarking on any large-scale treatment project.

Green Project coordinators had no direct contact with the Saskatoon soil scientists in 2014.

With the thought that tree-rings would likely preserve a record of changes in air-borne metal particulates over time, the Green Project asked Donna Lundquist of the Saskatchewan Ministry of Environment to do some coring to determine age ranges of trees in our area. Any future dendrochemical study would need to have access to trees significantly older than say 90 years (that is, they would have been well established prior to the start of local smelting operations in 1930). Trees in the immediate Flin Flon – Creighton area tended to be not more than about 65 years old – but some within 25 kilometres of the smelter complex are as much as 150 years old, and so might be suitable for such a study.

A study carried out on behalf of HMI by Intrinsik Environmental Sciences Inc. on the health implications of elevated levels of some metals and other elements in the soils of Flin Flon and Creighton, was referred to in our 2007-2010 Reports of Activities. The final study report was released in June, 2010. This, together with other information on the study is available at www.flinflonsoilsstudy.com.

Photography

Pairs of 'before-and-after' pictures illustrate in a dramatic way how effective the limestone treatment is proving to be. At left above is a view looking north at our Hapnot area taken in August, 2002 – the area had been treated earlier that year. At right is the same scene in August this year. During our first fourteen project years we took 2,483 pictures, and in 2014 we took an additional 111. These will serve as a permanent record of the project, and are being used for public relations purposes.

Public Relations

The Green Project was featured in the latest edition of the Flin Flon, Creighton & Area Tourism Guide. A brief reference was made to the Green Project under the header 'How do you make the most of summer … ' in the June 25 edition of The Reminder. We made posters and brochures which were distributed to local schools. Our web-site – www.greenproject.ca – has been updated and can now be adjusted for viewing on desktop computers, tablets and on mobile phones.

Future Plans

In 2015, we plan to extend coverage at our Phantom, Esso, Icehouse, Soccer and Rock Cut Middle areas, and to start work at the new 'Linda' area – above the North Avenue Park.

Additional Information

Please contact project coordinators:

Dave Price: (204) 687-8653 (work and home),
E-mail: dpprice@mymts.net

Heather Acres:
E-mail: heather.a.acres@gmail.com

and check out our web site at: www.greenproject.ca

APPENDIX 1: Organizational Background and Procedures

In the late 1960s and early 1970s, botanists at Laurentian University – among them our technical consultant, the late Professor Keith Winterhalder – found that the application of crushed limestone to the barren acidified and metal-contaminated soils around Sudbury led to the regeneration of vegetation. A major program of limestone application since then has led to a transformation of the Sudbury landscape.

In the early 1990s, Rena Gummerson and later Cathy Hynes of the Creighton/Denare Beach Economic Development Committee contacted Professor Winterhalder to see if he might be interested in helping to set up a re-vegetation program in our area. This resulted in his first visit up here in 1994. In 1999, Heather Acres and Clarence Pettersen of Flin Flon School Division thought that re-vegetation would be a good project for their Youth Mentor program, and the Green Project was launched with the support of the School Division. Hudson Bay Mining and Smelting Company Ltd. (now Hudbay Minerals Inc. - HMI) and the Flin Flon Economic Development Commission generously provided funding to bring Professor Winterhalder up here in October 1999. He spoke to a number of groups and generated a high level of interest and enthusiasm. A community-based consultation group was formed, and planning meetings were held in March and April 2000. McKeen's Trucking generously donated 130 yards of crushed limestone, and this allowed us to put our first groups of students to work in the field in May of that year.

Present members of the consultation group are: Flin Flon School Division, Creighton School Division, City of Flin Flon, Town of Creighton, Flin Flon and District Environment Council, HMI, Saskatchewan Ministry of Environment, and various community group leaders and members.

The first stage in planning our field operations involves checking out maps and air photographs. From these we get a general idea as to which areas might be suitable for treatment. We then ground-check the areas. Once their suitability has been confirmed, the crushed limestone is trucked in. Volunteers fill their pails at the dumps and spread the limestone as evenly as possible. The coordinator/supervisor makes sure no gaps are left. Work continues until the designated area is completely covered.

APPENDIX 2: Environment and Science

In and around the communities of Flin Flon and Creighton[1], there are large areas with little or no vegetation. Old tree stumps show that these areas were once forested.

In the 1920s and '30s when our communities and the smelter complex were first established, many trees were cut for fuel and lumber. Others were cut to make fire breaks, or were burned in forest fires. As production from the Flin Flon and other mines increased, so did the amount of sulphur dioxide smoke from the smelter. The smoke is harmful to vegetation, so the forest was not able to recover. The increasing acidity and metal content of the soil meant that only a very few hardy types of plant were able to survive. As the plants died, the thin topsoil washed away.

High levels of metals such as copper and zinc in the soil are toxic to plants[2]. This toxicity is accentuated by acidity, which makes the metals more soluble, and therefore more accessible. When seeds germinate in metal-contaminated soil, growth stops immediately on contact with the toxic soil solutions. The carbonate ion in the limestone tends to neutralize soil acidity, thus making the metals less soluble, and less toxic. Another component of the limestone, calcium, contributes to reducing soil toxicity by competing with zinc ions for uptake by plant roots. Calcium ions also have a strengthening effect on the plasma membranes in the root cells. This membrane is responsible for determining what is absorbed by the roots.

Since the early 1970s, Hudson Bay Mining and Smelting Company Ltd. (now Hudbay Minerals Inc. - HMI) spent hundreds of millions of dollars on improving technology at the smelter complex, with the result that emissions of sulphur dioxide and metal oxide dust were significantly reduced. The natural vegetation started to slowly recover. Our project is accelerating this recovery. In June 2010, the copper smelter was closed down, resulting in a complete cessation of gaseous and particulate emission from the stack.

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[1] *Flin Flon and Creighton are situated on either side of the Manitoba/Saskatchewan boundary about 600 kilometres north of the Canada/US border. A large copper-zinc ore body was discovered at Flin Flon in 1915, and production – which started in 1930 – continues to the present day.*

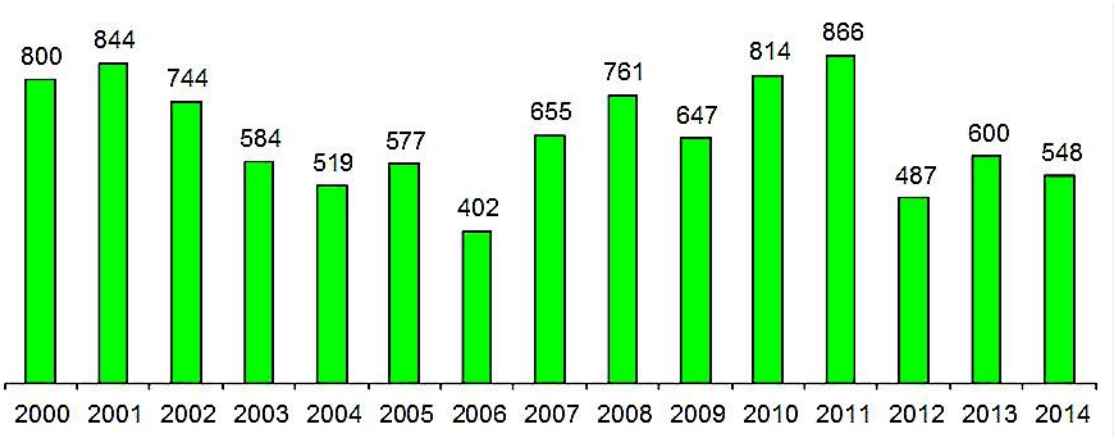
[2] *This paragraph is from information supplied by the late Professor Winterhalder.*

APPENDIX 3:

Personnel Summary Tabulation ~ 2014

Group	Sessions	Number*1
McIsaac School	10	226
Ruth Betts School	7	142
Creighton School	5	133
Hapnot Collegiate	1	6
FFRec-SITP*2	1	17
FFCYRC*3	2	24
Total	**26**	**548**

Personnel Distribution ~ 2000-2014



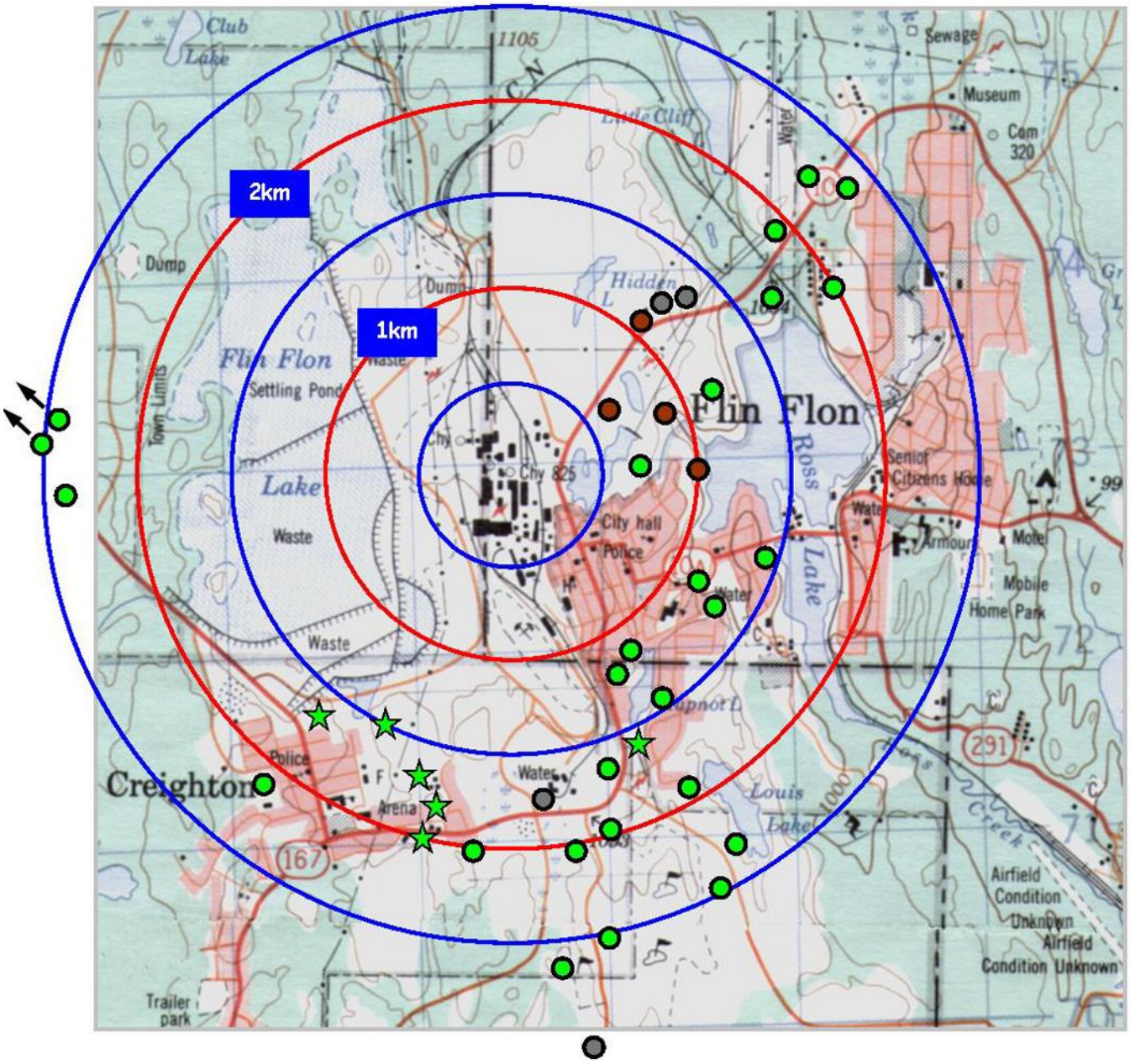
Total to date ~ 9,848*1

*1 *Because some individuals worked in more than one session, the actual number of participants in the Green Project is less than this.*

*2 *City of Flin Flon – 'Summer-in-the-Parks' program*

*3 *Flin Flon Community Youth Resources Centre*

APPENDIX 4: Vegetation-Cover Status by Area at Fall, 2014



Green stars – best, green circles – good, gray circles – promising, brown circles – poorest, open circles – awaiting results.

Large circles are centred on HMI's stack (half-kilometre intervals).