NATIVE PRAIRIE RESTORATION ALONG TRANSMISSION LINE CORRIDORS IN SOUTHERN MANITOBA: A PLANNING FRAMEWORK

A practicum submitted in partial fulfillment of the requirements
for the degree, Master of Natural Resources Management

Submitted by: Cameron William Faminow

Natural Resources Institute
University of Manitoba
Winnipeg, Manitoba, Canada
April, 1993

ISBN 0-315-86138-X

Name Cameron William Faminow

Dissertation Abstracts International is arranged by broad, general subject categories. Please select the one subject which most nearly describes the content of your dissertation. Enter the corresponding four-digit code in the spaces provided.

Native Prairie Restoration (Environmental Sciences) 0768 U·M·I

SUBJECT TERM SUBJECT CODE

Subject Categories

THE HUMANITIES AND SOCIAL SCIENCES

COMMUNICATIONS AND THE ARTS
- Architecture 0729
- Art History 0377
- Cinema 0900
- Dance 0378
- Fine Arts 0357
- Information Science 0723
- Journalism 0391
- Library Science 0399
- Mass Communications 0708
- Music 0413
- Speech Communication 0459
- Theater 0465

EDUCATION
- General 0515
- Administration 0514
- Adult and Continuing 0516
- Agricultural 0517
- Art 0273
- Bilingual and Multicultural 0282
- Business 0688
- Community College 0275
- Curriculum and Instruction 0727
- Early Childhood 0518
- Elementary 0524
- Finance 0277
- Guidance and Counseling 0519
- Health 0680
- Higher 0745
- History of 0520
- Home Economics 0278
- Industrial 0521
- Language and Literature 0279
- Mathematics 0280
- Music 0522
- Philosophy of 0998
- Physical 0523
- Psychology 0525
- Reading 0535
- Religious 0527
- Sciences 0714
- Secondary 0533
- Social Sciences 0534
- Sociology of 0340
- Special 0529
- Teacher Training 0530
- Technology 0710
- Tests and Measurements 0288
- Vocational 0747

LANGUAGE, LITERATURE AND LINGUISTICS
- Language
  - General 0679
  - Ancient 0289
  - Linguistics 0290
  - Modern 0291
- Literature
  - General 0401
  - Classical 0294
  - Comparative 0295
  - Medieval 0297
  - Modern 0298
  - African 0316
  - American 0591
  - Asian 0305
  - Canadian (English) 0352
  - Canadian (French) 0355
  - English 0593
  - Germanic 0311
  - Latin American 0312
  - Middle Eastern 0315
  - Romance 0313
  - Slavic and East European 0314

PHILOSOPHY, RELIGION AND THEOLOGY
- Philosophy 0422
- Religion
  - General 0318
  - Biblical Studies 0321
  - Clergy 0319
  - History of 0320
  - Philosophy of 0322
- Theology 0469

SOCIAL SCIENCES
- American Studies 0323
- Anthropology
  - Archaeology 0324
  - Cultural 0326
  - Physical 0327
- Business Administration
  - General 0310
  - Accounting 0272
  - Banking 0770
  - Management 0454
  - Marketing 0338
- Canadian Studies 0385
- Economics
  - General 0501
  - Agricultural 0503
  - Commerce-Business 0505
  - Finance 0508
  - History 0509
  - Labor 0510
  - Theory 0511
- Folklore 0358
- Geography 0366
- Gerontology 0351
- History
  - General 0578
  - Ancient 0579
  - Medieval 0581
  - Modern 0582
  - Black 0328
  - African 0331
  - Asia, Australia and Oceania 0332
  - Canadian 0334
  - European 0335
  - Latin American 0336
  - Middle Eastern 0333
  - United States 0337
- History of Science 0585
- Law 0398
- Political Science
  - General 0615
  - International Law and Relations 0616
  - Public Administration 0617
- Recreation 0814
- Social Work 0452
- Sociology
  - General 0626
  - Criminology and Penology 0627
  - Demography 0938
  - Ethnic and Racial Studies 0631
  - Individual and Family Studies 0628
  - Industrial and Labor Relations 0629
  - Public and Social Welfare 0630
  - Social Structure and Development 0700
  - Theory and Methods 0344
- Transportation 0709
- Urban and Regional Planning 0999
- Women's Studies 0453

THE SCIENCES AND ENGINEERING

BIOLOGICAL SCIENCES
- Agriculture
  - General 0473
  - Agronomy 0285
  - Animal Culture and Nutrition 0475
  - Animal Pathology 0476
  - Food Science and Technology 0359
  - Forestry and Wildlife 0478
  - Plant Culture 0479
  - Plant Pathology 0480
  - Plant Physiology 0817
  - Range Management 0777
  - Wood Technology 0746
- Biology
  - General 0306
  - Anatomy 0287
  - Biostatistics 0308
  - Botany 0309
  - Cell 0379
  - Ecology 0329
  - Entomology 0353
  - Genetics 0369
  - Limnology 0793
  - Microbiology 0410
  - Molecular 0307
  - Neuroscience 0317
  - Oceanography 0416
  - Physiology 0433
  - Radiation 0821
  - Veterinary Science 0778
  - Zoology 0472
- Biophysics
  - General 0786
  - Medical 0760

EARTH SCIENCES
- Biogeochemistry 0425
- Geochemistry 0996
- Geodesy 0370
- Geology 0372
- Geophysics 0373
- Hydrology 0388
- Mineralogy 0411
- Paleobotany 0345
- Paleoecology 0426
- Paleontology 0418
- Paleozoology 0985
- Palynology 0427
- Physical Geography 0368
- Physical Oceanography 0415

HEALTH AND ENVIRONMENTAL SCIENCES
- Environmental Sciences 0768
- Health Sciences
  - General 0566
  - Audiology 0300
  - Chemotherapy 0992
  - Dentistry 0567
  - Education 0350
  - Hospital Management 0769
  - Human Development 0758
  - Immunology 0982
  - Medicine and Surgery 0564
  - Mental Health 0347
  - Nursing 0569
  - Nutrition 0570
  - Obstetrics and Gynecology 0380
  - Occupational Health and Therapy 0354
  - Ophthalmology 0381
  - Pathology 0571
  - Pharmacology 0419
  - Pharmacy 0572
  - Physical Therapy 0382
  - Public Health 0573
  - Radiology 0574
  - Recreation 0575
  - Speech Pathology 0460
  - Toxicology 0383
- Home Economics 0386

PHYSICAL SCIENCES

Pure Sciences
- Chemistry
  - General 0485
  - Agricultural 0749
  - Analytical 0486
  - Biochemistry 0487
  - Inorganic 0488
  - Nuclear 0738
  - Organic 0490
  - Pharmaceutical 0491
  - Physical 0494
  - Polymer 0495
  - Radiation 0754
- Mathematics 0405
- Physics
  - General 0605
  - Acoustics 0986
  - Astronomy and Astrophysics 0606
  - Atmospheric Science 0608
  - Atomic 0748
  - Electronics and Electricity 0607
  - Elementary Particles and High Energy 0798
  - Fluid and Plasma 0759
  - Molecular 0609
  - Nuclear 0610
  - Optics 0752
  - Radiation 0756
  - Solid State 0611
- Statistics 0463

Applied Sciences
- Applied Mechanics 0346
- Computer Science 0984
- Engineering
  - General 0537
  - Aerospace 0538
  - Agricultural 0539
  - Automotive 0540
  - Biomedical 0541
  - Chemical 0542
  - Civil 0543
  - Electronics and Electrical 0544
  - Heat and Thermodynamics 0348
  - Hydraulic 0545
  - Industrial 0546
  - Marine 0547
  - Materials Science 0794
  - Mechanical 0548
  - Metallurgy 0743
  - Mining 0551
  - Nuclear 0552
  - Packaging 0549
  - Petroleum 0765
  - Sanitary and Municipal 0554
  - System Science 0790
- Geotechnology 0428
- Operations Research 0796
- Plastics Technology 0795
- Textile Technology 0994

PSYCHOLOGY
- General 0621
- Behavioral 0384
- Clinical 0622
- Developmental 0620
- Experimental 0623
- Industrial 0624
- Personality 0625
- Physiological 0989
- Psychobiology 0349
- Psychometrics 0632
- Social 0451

NATIVE PRAIRIE RESTORATION ALONG TRANSMISSION LINE CORRIDORS IN SOUTHERN MANITOBA: A PLANNING FRAMEWORK

By

Cameron William Faminow

A practicum submitted to the Faculty of Graduate Studies of the University of Manitoba in partial fulfillment of the requirements for the degree of Master of Natural Resources Management.

Abstract

This study was undertaken to determine the feasibility of using hydro transmission line rights-of-way as a medium for native prairie restoration and habitat patch connection in southern Manitoba. It was determined that very little native vegetation remained within the study area, primarily due to intensive agricultural practices.

Transmission line rights-of-way passing through lands of relatively marginal agricultural capability were analyzed in terms of their potential for prairie restoration and patch connection. While the potential for native prairie restoration was high, few sites within the study area offered good opportunity to test patch connection theory.

Prior to any large capital investment for a prairie restoration project, it was determined that a pilot study should be completed. Test sites were identified within four study zones and an experiment was designed. The pilot study would require approximately seven years to complete and would provide the participants in the project with valuable information on native prairie restoration in southern Manitoba. This information is currently absent in the scientific literature.

It was concluded that benefits of native prairie restoration could be realized by wildlife, rights-of-way managers, agriculturalists, and society in general. It was also recognized that there may be unforseen additional costs, as well as potential problems associated with a long-term native prairie restoration project.

Findings from this study and previous research can be used as a framework for rights-of-way managers, who can apply the information in the planning and maintenance of existing and future rights-of-way.

Acknowledgements

I would first like to thank Manitoba Hydro for giving me the opportunity to pursue this project, as well as for providing me with the financial assistance needed. It is hoped that this practicum will provide them with a new option, which they may use to compliment their already strong environmental policy. I would also like to thank the people of Manitoba Hydro, many of which I did not meet, that provided me with outstanding technical support. Your speed and professionalism are greatly appreciated.

It is with much gratitude that I acknowledge the efforts of my academic committee including my faculty advisor, Dr. Richard Baydack of the Natural Resources Institute, Mr. Roy Bukowsky of Manitoba Hydro, Professor Rea Josephson of the Department of Agricultural Economics, Ms. Ruth Marr of Marr Consulting and Communications, and Dr. Ray England of Toad Hall Toys. Their patience, accessibility, and individual contributions allowed me to produce a document of which I am proud in a most timely fashion.

I would also like to thank all my friends and colleagues at the Natural Resources Institute for helping me through my "adventures" during my time in Winnipeg. Particular thanks to Ms. Kate Hearn, Ms. Sheryl Hellman, and Ms. Judi Zieske.

Most important was the support of my family, both here and in Alberta. To my parents Marg and Bill, my sisters Sandy and Fern, and my brother Cal, thank you for all you have done. To my brother Merle, Bia, and Ana, *muito obrigado*. This practicum is ultimately the product of your support.

Table of Contents

List of Figures

List of Tables

Glossary of Terms

Aspen Parkland — The transitional area between boreal forest and grassland, characterized by an abundance of Aspen Poplar (*Populus tremuloides*).

Chernozem — Well to imperfectly drained soils having surface horizons darkened by the accumulation of organic matter derived from the decomposition of grasses and forbs.

Degree Day — The accumulation of degrees of temperature above a daily mean of 5.6 degrees Celsius (the minimum temperature needed for plant growth).

Disturbance — A sudden environmental change, which can be either natural or human in nature.

Edge Effect — A difference in species composition and abundance along the edge of a patch or corridor.

Gleysol — Poorly drained soils having features reflecting saturation such as dull grey and mottled subsoils.

Grassland — A plant community dominated by perennial grasses, not representative of a prairie, whether deliberately established by humans or not.

Matrix — A community which has a dissimilar community structure or composition than a patch or corridor.

Patch — A community or species assemblage surrounded by a matrix with dissimilar community structure or composition.

Prairie — An original, or authentic, plant community dominated by perennial grasses and forbs with woody plants limited to low growing shrubs.

Regosol — Well to imperfectly drained soils having columnar B horizons that are hard when dry and that swell to a sticky mass of a very low permeability when wet.

<u>Restoration</u> The recreation of (or attempt to recreate) an authentic plant community on a site where that particular community no longer exists.

<u>Revegetation</u> The establishment of a vegetative cover not representative of an authentic plant community on a non-vegetated site.

Chapter 1. Introduction

1.1 Preamble

Since the arrival of the first settlers, Canada's prairie grassland region has been severely altered. This was primarily the result of agricultural practices throughout the prairie provinces. Approximately 44 percent of what was native prairie grasslands is now cultivated cropland, and less than 5 percent of Canada's prairie region is presently protected from further development (Government of Canada, 1991). Southern Manitoba's native prairies are in a similar state. Since the 1870's, the southern Manitoba landscape has been developed, primarily for agricultural purposes. Most of the land is considered productive for agriculture, and consequently has been cleared for crop production. This has reduced the total area of native prairie, which at one time dominated the landscape. Presently, 88 percent of Manitoba's prairie is cultivated cropland (Government of Manitoba, 1991). Tall grass prairie, found only in Manitoba, is considered the rarest in Canada, with only a fraction of one percent remaining (Government of Canada, 1992). Mixed grass prairie has been significantly reduced in area, and what remains is often subject to overgrazing by cattle (Government of Canada, 1992).

Recently, public attitudes have been changing in relation to development in the grassland regions. More emphasis is being placed on the conservation, preservation, and restoration of native prairie (Appendix 1). The agriculture industry is also re-evaluating its development and maintenance procedures, particularly in the use of herbicides.

The potential exists in southern Manitoba to use power line rights-of-way as a medium for the restoration and/or protection of vegetation which has been depleted over the years. The condition of native prairie in southern Manitoba is in a serious stage in terms of both quality and quantity. Restoration along rights-of-way may significantly aid in its re-establishment. This will not only benefit plant and wildlife species, but may also provide a right-of-way management alternative which is both cost-effective and environmentally preferable.

1.2 Statement of Problem

Relatively few areas of native vegetation remain in southern Manitoba. Species migration and diversity may be impeded due to lack of habitat or isolation of native vegetation patches in relation to each other. The remaining native vegetation patches are scattered in terms of size, number, location, and composition. A study is necessary which will examine the potential of rights-of-way, particularly power transmission lines, to be used as a medium for native prairie restoration and patch connection.

1.3 Objectives

The purpose of this study was to: a) determine if practical application of vegetation patch theory, using transmission line rights-of-way, can occur within the study area and; b) provide a planning framework for native prairie restoration along line rights-of-way in southern Manitoba. Specific objectives included:

1. **Identify zones within the study area which may be suitable for prairie restoration;**
2. **Determine the native vegetation types (general) within these areas prior to agricultural development;**
3. **Identify existing power transmission lines with 30 metre rights-of-way;**
4. **Identify areas along transmission lines suitable for prairie restoration;**
5. **Provide recommendations for future rights-of-way planning in southern Manitoba.**

1.4 Study Area

Figure 1 indicates the study area selected. The area lies between Winnipeg and Brandon, south of Lake Manitoba. It encompasses 156 full townships and 6 partial townships. It was selected primarily because:

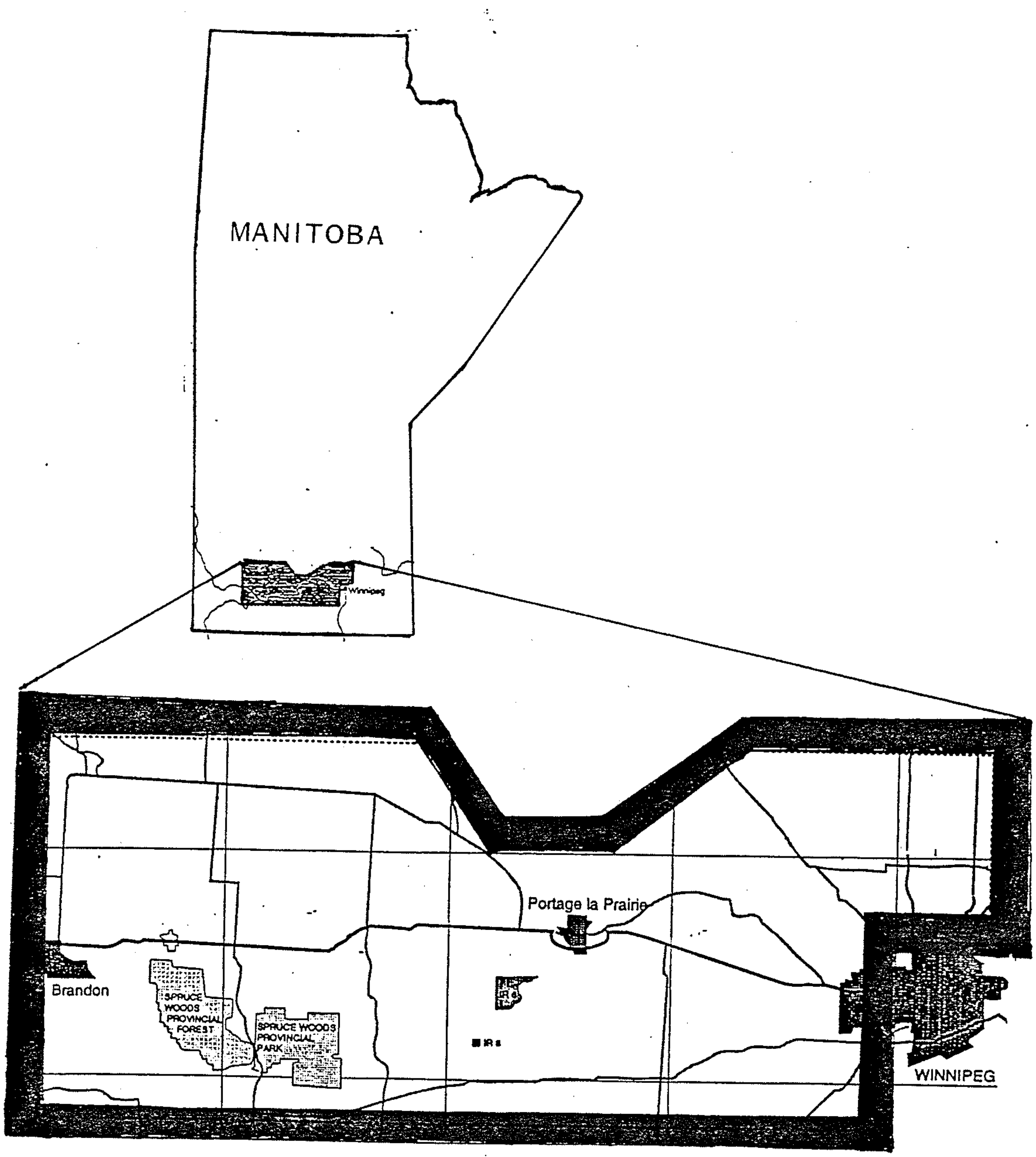
1) it encompassed historical tall and mixed grass prairie zones;

2) the large number of transmission lines within it;

3) the intensive agriculture which has greatly reduced the amount of native vegetation within the area;

Figure 1.

Prairie Restoration Study Area



1.4.1 Vegetation

The study area falls within the boundaries of the area historically designated as the aspen parkland, which was "situated between the great plains of central North America and the coniferous forest of the Pre-Cambrian Shield" (Bird, 1961;1). The aspen parkland contained two major plant communities, grassland and forest, which were intermingled throughout the landscape. The study area is now predominantly cultivated cropland.

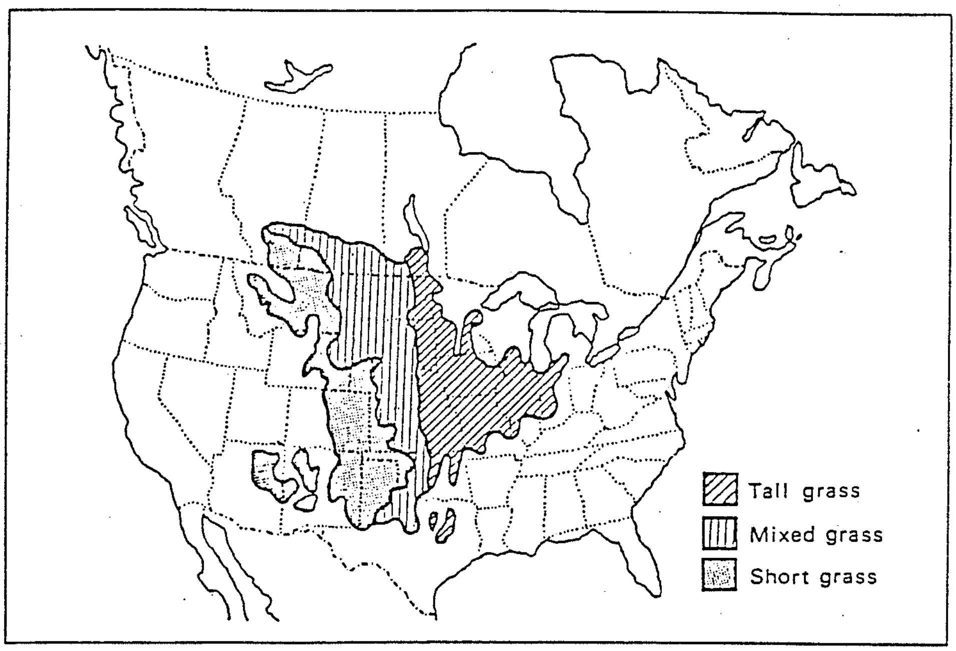
Grassland

The grassland historically included both tall grass and mixed grass prairie (within the aspen parkland). Tall grass prairie differs from mixed grass and short grass prairies in its soil type and related soil moisture (Leskiw, 1978). The largest proportion of mesic prairie plant species are the forbs, followed by legumes and finally the grasses. Indicator grass species of tall grass prairie include big bluestem (*Andropogon geraldi*), Canadian wild rye (*Elymus canadensis*), needlegrass (*Stipa spartea*) and switchgrass (*Panicum virgatum*). Dominant forbs include the asters (*Aster spp.*), and goldenrods (*Solidago spp.*) (Weaver, 1954).

The mixed grass prairie is considered a transition zone between the tall grass prairie to the east and the short grass prairie to the west. It is found on the western side of the study area. Shorter species of grass, such as little bluestem (*Andropogon scoperius*) become dominant, and forb and legume species become less common and smaller in size (Leskiw, 1978). Moisture retention properties of soil determine what plant species dominate any particular area (Watts, 1969). Blue gramma grass (*Bouteloua gracilis*) will be found in areas with sandy loam soils, while speargrass (*Stipa comata*) and western wheatgrass (*Agropyron smithii*) dominate the clay-loam soils with poor drainage. Figure 2 indicates the historic distribution of major prairie types in North America.

Figure 2

Historical Distribution of Major Prairie Types in Manitoba



From Joyce (1990)

Until recently, restoration of native prairie, and ecosystems in general, was not given much credence by the scientific community (Collicutt and Morgan, 1990). While the importance of grasslands and prairies can be practical (economical), to prevent soil erosion for example, it is also valuable as habitat for wildlife species and, as in the case of tall grass prairie, is important as a unique ecological entity.

Forest Communities

Bird (1961) subdivides the parkland forest into six lesser communities including (a) aspen poplar, (b) maple, ash, and elm floodplain, (c) bur oak, (d) willow, (e) white spruce sand hill, and (f) tamarack-black spruce.

<u>Aspen Poplar Community</u>

The parkland is where the aspen poplar (*Populus tremuloides*) reaches its greatest abundance, predominating over other communities. Aspen poplar is considered climax when in contact with prairie communities, although its succession may be slowed or even reversed in periods of drought. In well-drained soils it will grow in pure stands, while in poorly-drained soils it is commonly associated with the balsam poplar (*Populus balsamifera L.*).

The shrub stratum in the aspen poplar community is primarily composed of hazelnut (*Corylus americana*), red osier dogwood (*Cornus stolonifera*), and highbrush cranberry (*Viburnum opulus*) (commonly found within the woods), and rose (*Rosa spp.*), choke cherry (*Prunus virginiana*), pin cherry (*Prunus pensylvania*), saskatoon berry (*Amelanchier alnifolia*), and snowberry (*Symphoricarpos occidentalis*) (found on the forest edges).

The forbs consists primarily of wild sarsparilla (*Aralia nudicaulis*), red baneberry (*Actaea rubra*), Lindley's aster (*Aster lindleyanus*), and sweet-scented bedstraw (*Galium triflorum*). In areas of sandy soil these may be replaced by poison ivy (*Rhus radicanus*).

Maple, Ash, and Elm Floodplain Community

This community occupies floodplains such as the Assiniboine River in southern Manitoba. The principle trees include the Manitoba maple (*Acer negundo*), lance-leaved ash (*Fraxinus pennsylvanica*), and the American elm (*Elmus americana*). Other less common trees include the cottonwood (*Populus sargentii*) and the basswood (*Tilia americana*). Willow (*Salix spp.*) may be found on the river banks or sandbars. Undergrowth is meagre in the floodplain forest, although there may be patches of ostrich fern (*Pteretis pensylvanica*) or wood nettle (*Loportea canadensis*).

Bur Oak Community

The bur oak (*Quercus marcocarpa*) is found in abundance in the Winnipeg and Portage La Prairie areas, but is also found in Spruce Woods Provincial Park. The oak generally grows on the south and west slopes of hills and valleys.

Willow Communities

Willow (*Salix spp.*) communities are common in the aspen parkland. The sandbar willow (*Salix interior*) grows in heavy stands along sandbars and river banks. The basket willow (*Salix petiolaris*) is found around sloughs. The pussy willow (*Salix discolor*) grows in low but better-drained soils than the other species, such as the transition zone between sloughs and forest or grassland.

White Spruce Sand Hill Community

Scattered stands of white spruce (*Picea glauca*) intermixed with aspen are found in the sand hill area of south-central Manitoba, which includes Spruce Woods Provincial Park. Within climax stands of spruce, fallen needles prevent the growth of herbaceous plant species, while in subclimax stands creeping juniper (*Juniperus horizontalis*), bearberry (*Arctostaphylos uva-ursi*), and poison ivy may be found.

Tamarack-Black Spruce Swamp Community

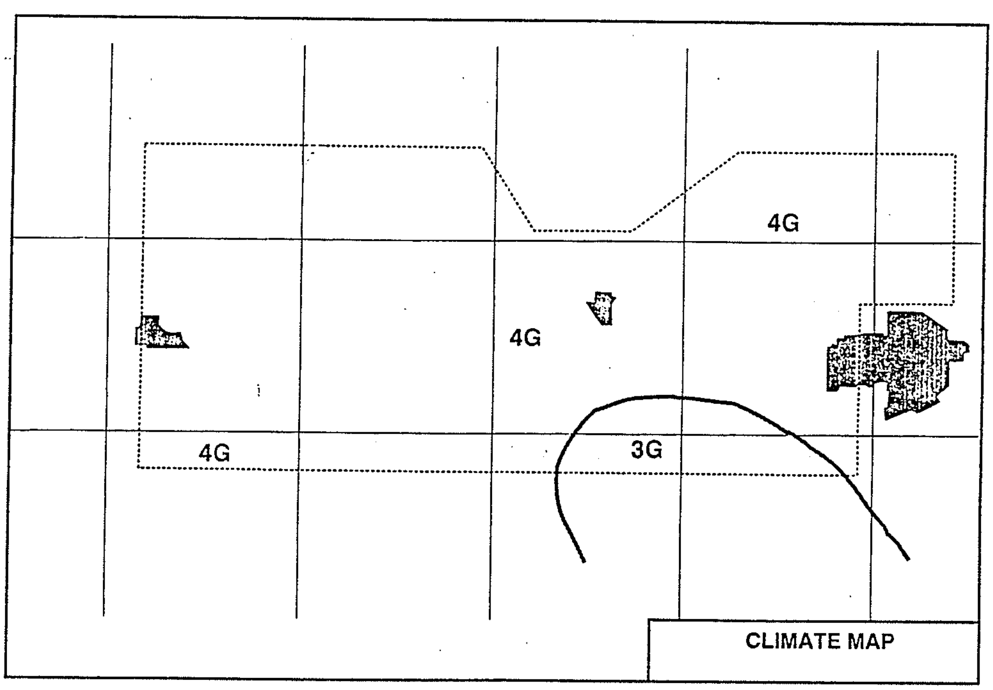
Although this community is less common in the aspen parkland, it does occur within it, particularly along the Assiniboine River within Spruce Woods Provincial Park. Tamarack (*Larix laricina*) grows in the wetter areas of swamps where there is standing water. Black spruce (*Picea mariana*) grows on slightly higher land. As the water table lowers, tamarack is replaced by black spruce.

Black spruce grows so tightly together that shrub and herbaceous growth is not possible. The tamarack, however, allows the growth of Labrador tea (*Ledum groenlandicum*), dwarf birch (*Betula glandulosa*), and sphagnum (*Sphagnum spp.*).

1.4.2 Climate

Figure 3 indicates major climatic regions within the study area. Area 3G is characterized by an average of 3100 degree days (above 5.6°C) and an average precipitation of 304.8 mm (May - September). Area 4G is characterized by 2800 degree days and an average precipitation of 304.8. Mean summer temperature is 19°C while mean winter temperature is 16.7°C (Government of Manitoba, 1983; pg. 10).

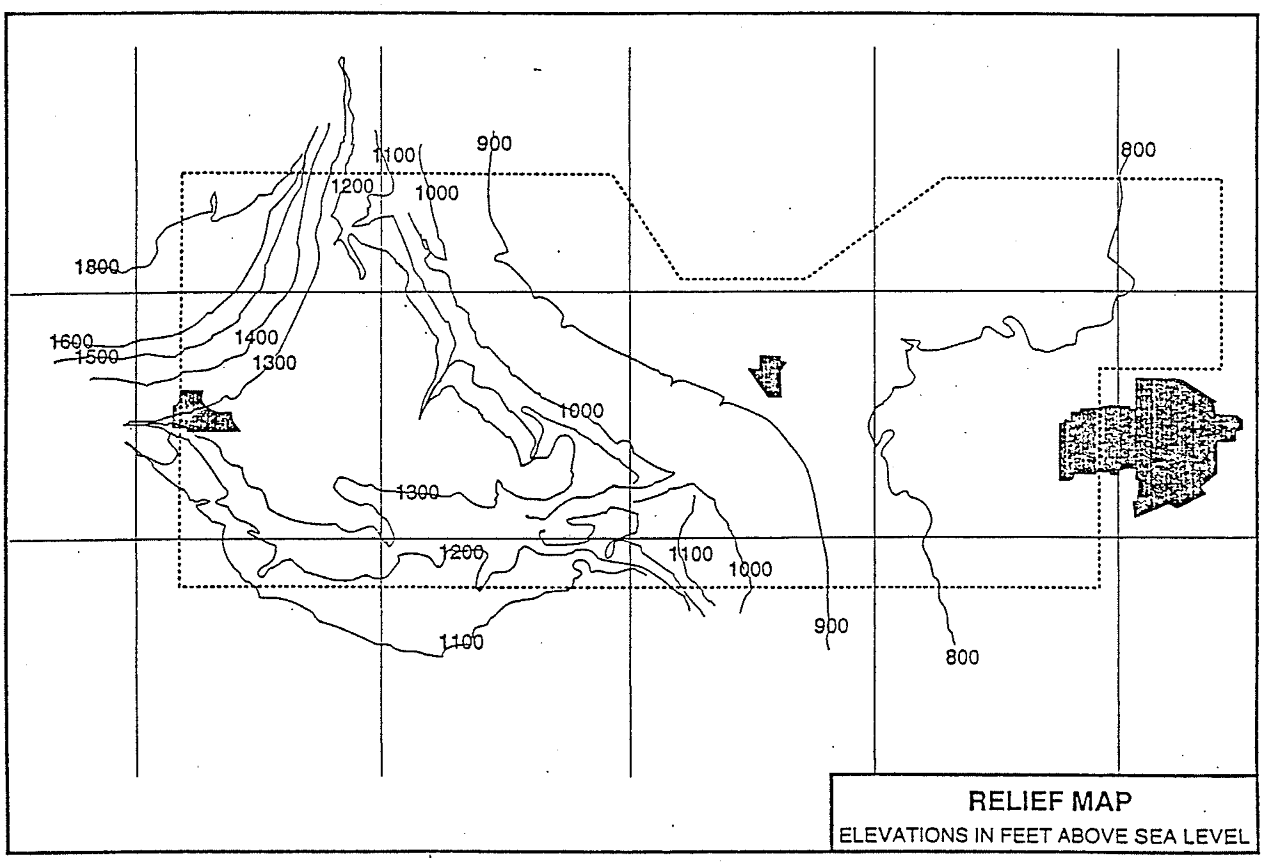
Figure 3. Climatic Regions



1.4.3 Topography

The majority of the study area lies on the physiographic region called the Manitoba lowland (Figure 4) with approximately one quarter occupying the western upland. The lowland represents a long deposition history while it was covered by glacial lake Agassiz. The Western Upland runs from the Manitoba/U.S. border northwest to the Saskatchewan border (Government of Manitoba, 1983; pg. 5).

Figure 4

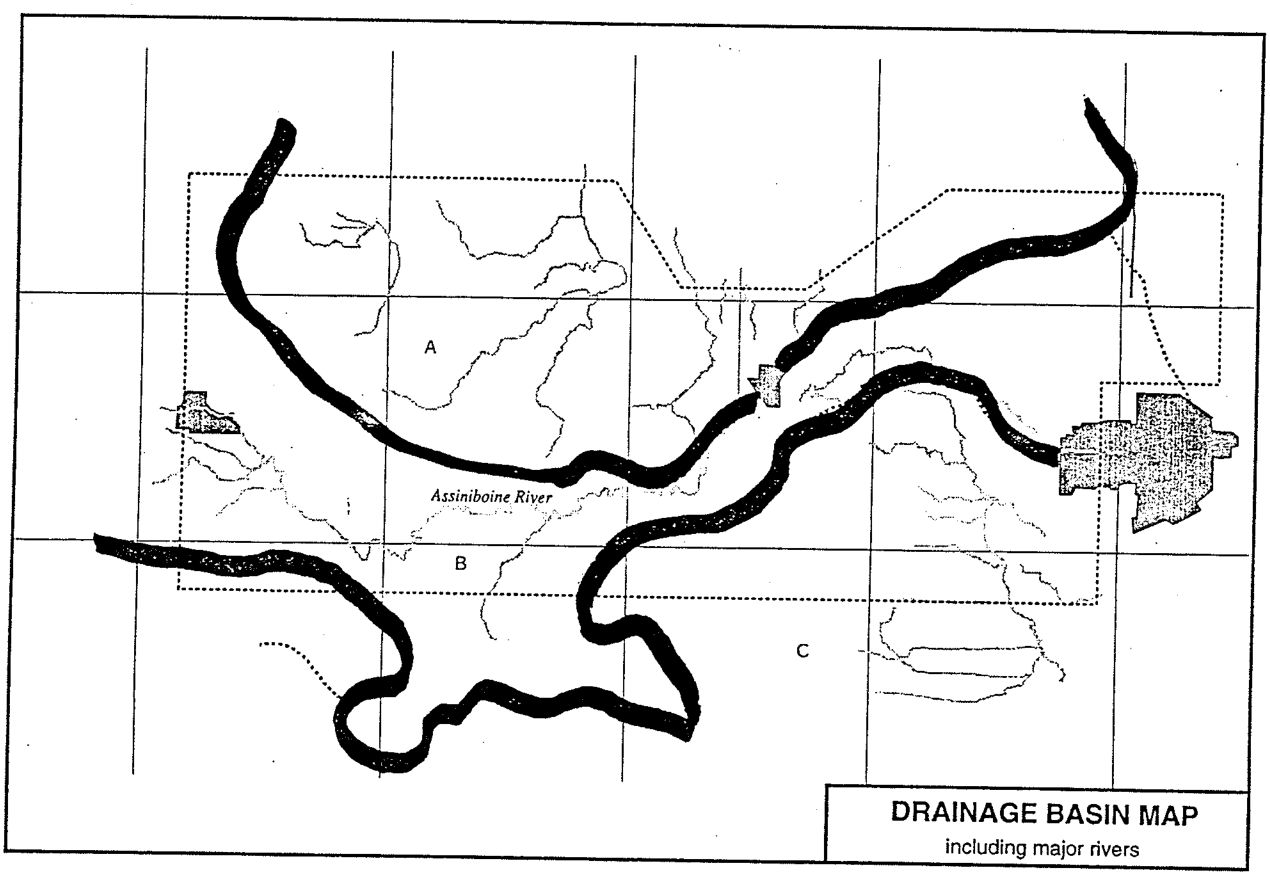


Scale 1 cm. = 16.7 kilometres

1.4.4 Hydrology

The study area includes three drainage subdivisions. Watershed **A** drains into lake Manitoba, Watershed **B** into the Assiniboine River, and **C** drains into the Red River (Figure 5).

Figure 5



Scale 1 cm = 16.7 kilometres

1.4.5 Soils

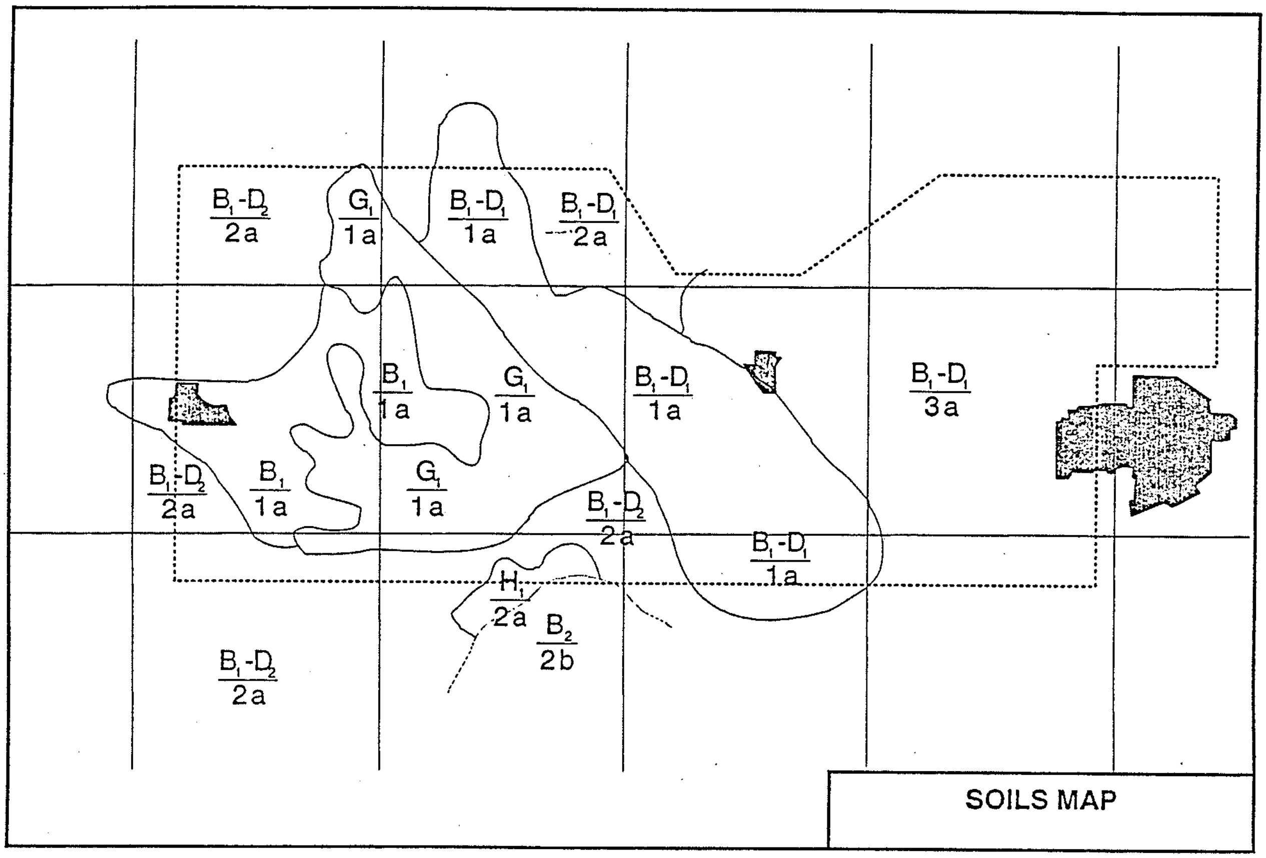
The predominant soil types are black chernozems and humic gleysols. Chernozems are characterized as being "well to imperfectly drained mineral soils having surface horizons darkened by the accumulation of organic matter derived from the decomposition of grasses and forbs" (Government of Manitoba, 1983, pg. 13).

Gleysols are described as "poorly drained soils having features reflecting saturation such as dull grey and mottled subsoils", and are generally found in shallow depressions and flat areas prone to spring flooding.

Other soil types found in the study area include regosols, which are well to imperfectly drained and lack profile development, and solonetzic soils, which are "well to imperfectly drained mineral soils having B horizons that are hard when dry and that swell to a sticky mass of a very low permeability when wet".

Soil textures vary within the region but are generally coarse in the east portion of the study area and fine in the west. Soil classifications within the study area are identified in Figure 6.

Figure 6



Scale 1 cm. = 16.7 kilometres

<u>Soil Types</u>	<u>Texture and Topography</u>
B1 = Black chernozem	**1a** = Course/level to undulating
D1 = Humic gleysol	**2a** = Medium/level to undulating
G1 = Orthic regosol	**3a** = Fine/level to undulating
H1 = Black solonetzic	

1.5 Manitoba Hydro Maintenance Policy

Manitoba Hydro's vegetation management programs vary from no management in agricultural areas to extensive management in forest regions (Mann, 1992). Management programs are site-specific depending on size of power line, type of vegetation, location of line, soil type, and landowner permission.

1.5.1 Right-of-Way Size

The size of the rights-of-way are directly related to the voltage running through the line. Lines of 115 Kv or 230 Kv have rights-of-way of 100 feet (30 metres). These rights-of-way are required to prevent hazards, such as trees falling on lines, causing fires and power outages. They also must be wide enough for general maintenance and repairs or, in the event of an accident, for emergency vehicles, such as a helicopter.

1.5.2 Line Maintenance

Maintenance programs are most extensive in forested regions, with an objective of keeping vegetation below two meters. On a 230 Kv line, clearance between the line and vegetation must be at least 15 feet (4.5 metres). In prairie areas, rights-of-way maintenance is limited to ensuring access along the line. On cultivated agricultural land, no maintenance is necessary.

How the vegetation is managed depends mostly on its height. Herbicides are commonly used if the (tree) growth is less than two meters in height. If the vegetation is higher than two meters it will be mowed or cleared mechanically with any regrowth being treated with herbicides. The general problem species are trees which grow quickly and can reach considerable height. These include the black (balsam) poplar, trembling aspen, ash, cottonwood (which grows very quickly), spruces, and pines. Herbicide spraying for tree species can be either selective spraying or mass spraying, depending on the density. Selective spraying of herbicides is becoming more common (Mann, personal communication, 1993). Selective spraying is directed at the taller tree species, such as poplar and ash, while the shorter species such as dogwood or willow are left to grow. Additionally, herbicides used by Manitoba Hydro are specific to certain plant species. While they kill unwanted tree species they are designed to actually promote grass species propagation.

Chapter 2. Literature Review

2.1 Landscape Theory

As conservation and resource management concepts have evolved over time, greater emphasis is being placed on the ecosystem approach, which acknowledges human interactions with, and impacts on the resource base, rather than viewing people and their activities as separate from natural ecological processes (Jahn, 1991). This concept became popular following the formation of the *Great Lakes Water Agreement* in 1978. The need for understanding all processes and interactions associated with development placed greater emphasis on integrated resource management, which taps into the expertise of many disciplines for a more comprehensive decision-making process.

Forman and Godron (1981;733) define landscapes as

> "..ecological units with structure and function are composed primarily of patches in a matrix. Patches differ fundamentally in origin and dynamics, while size, shape, and spatial configuration are also important. Line corridors, strip corridors, stream corridors, networks, and habitations are major interactive structural characteristics of a landscape."

They suggest that within a landscape each cluster of stands would show "fluxes" of energy, mineral nutrients, and species between adjacent stands, indicating considerable interaction amongst these stands. Similar interactions would occur in other clusters within the landscape, until interrupted by a different landscape, either natural or human.

In 1989, a strategy emerged which redefined habitats to include the landscape concept to meet resource needs (Rodiek and Bolen, 1991). This strategy suggested applying the tools of planning, management, and design to the *entire* landscape, as opposed to isolated areas within it. Resource managers should consider two spatial manipulations which include wildlife, habitat, and human aspirations. The first requires that managers view the landscape as a continuous entity. The second requires the managers to organize the landscapes' form and function to include all concerned parties. The ultimate goal of the strategy is to perpetuate the landscape, not destroy it (Rodiek and Bolen, 1991).

Cain (1968) promoted the concept of integrating ecological principles and knowledge into human land use. These principles can then be applied to the management of natural resources as well as human resources, developing two types of landscapes; sustainable landscape mosaics and regenerated landscapes (Rodiek, 1991). Sustainable landscape mosaics are defined as

> "..the reformation of yet-to-be developed human landscape mosaics in and around the skeletal corps of natural ecosystems where the former subordinates their activities. In so doing, structure and function of the

area is given priority, and thereby a genuine social and institutional value" (page 7).

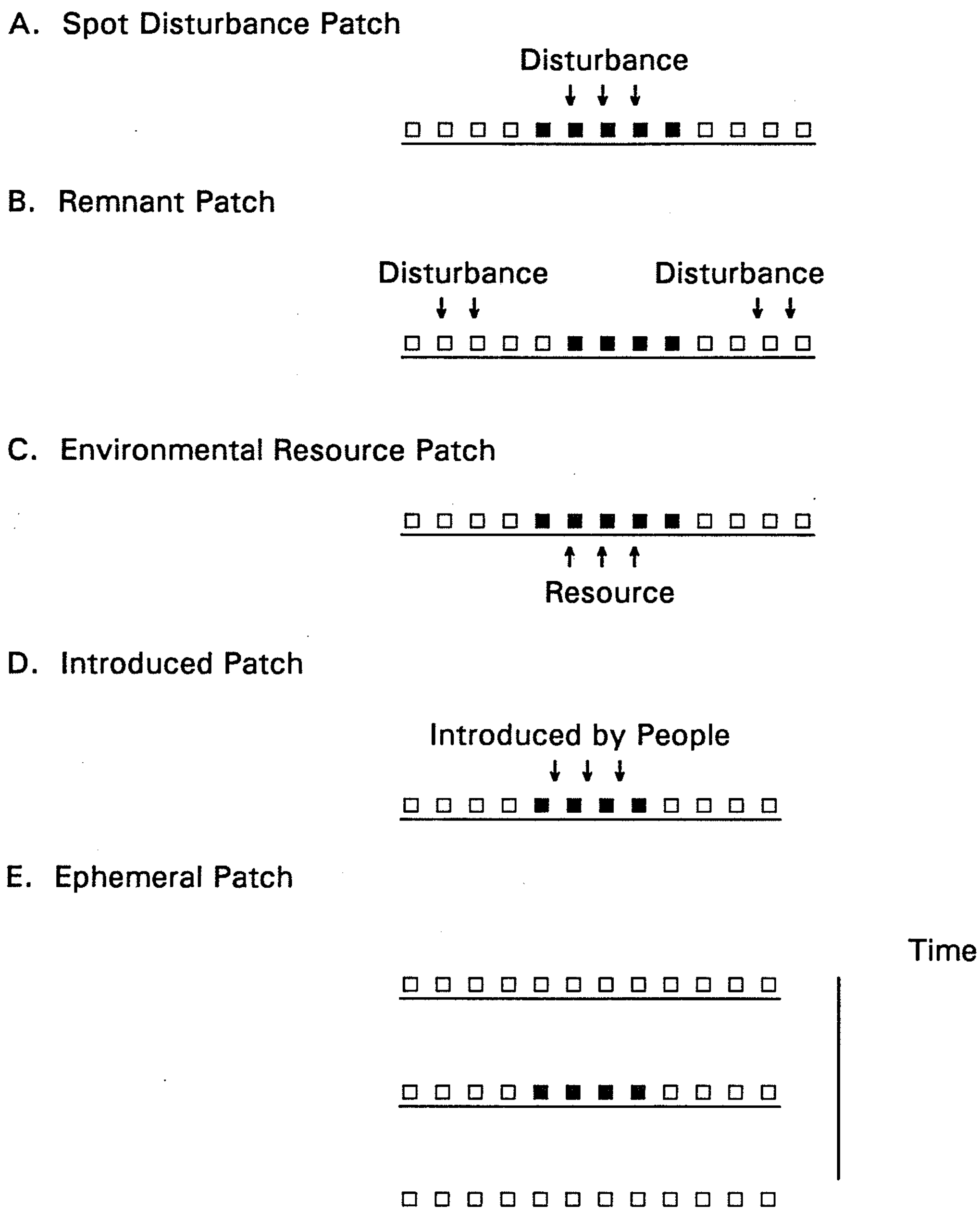
Vegetation manipulation within habitats to benefit specific types of wildlife could be considered a sustainable landscape mosaic.

Regenerated landscapes occur where ".. human dominated areas which still contain native flora and fauna are less intensely utilized". Habitats within these landscapes are allowed the opportunity to regenerate naturally, with the aid of some planting. Abandoned farmsteads with native plants could be considered an example.

2.2 Habitat Patches

Patches are defined as "..communities or species assemblages surrounded by a matrix with dissimilar community structure or composition" (Forman and Godron, 1981;734). Patches become distinct entities within a landscape mosaic which increase in focus with disturbance. Disturbance is defined as a "sudden environmental change", which can be either natural or human in nature. There are five distinct patch types, which differ in their dynamics and stability (Forman, 1979). These include the spot disturbance patch, remnant patch, environmental resource patch, introduced patch, and ephemeral patch (Figure 7).

Figure 7. Patch Types
From Forman and Godron (1981), p. 734



Patch origins. Species dynamics within a patch and turnover of the patch itself differ substantially according to the mechanisms causing a patch. □ □ □ = matrix;
■ ■ ■ = patch; disturbance = a sudden severe environmental change.

2.3 Patch Dynamics

Pickett and White (1985) suggest that patch community structure and behaviour will vary locally. General factors which influence the patch, and ultimately the landscape dynamics, include size, edge and shape, and numbers and configurations (Forman and Godron, 1981).

2.3.1 Patch Size

Patch size affects productivity, nutrient and water flux, and species dynamics (Forman and Godron, 1981). Further studies indicate a strong correlation between patch area size and species diversity (Gottfried, 1979; Moore and Hooper, 1975), but the need for more research is apparent (Clark and Nudds, 1991). Forman and Godron (1981;735) suggest:

Species Diversity = f(habitat diversity +/- disturbance + area + age + matrix heterogeneity - isolation - boundary discreteness)

\+ = positive relation

\- = negative relation

+/- = positive or negative

2.3.2 Patch Edge and Shape

Depending on the size of the patch, the habitat within may be quite different than along its' outer edge. This phenomenon is known as the "edge effect"; a difference in species composition and abundance along the edge of an area (Forman and Godron, 1981; Galli et.al., .976). The edge effect, in turn, has been found to be dependent on patch shape, as well as its size (Forman and Godron, 1981). A long, thin patch may have little or no edge habitat, while a large, round patch may have a considerable edge effect. The actual width of the edge may be affected by wind (Forman and Godron, 1981) or the angle of the sun (Wales, 1972), and may vary from a few meters to many meters.

2.3.3 Patch Numbers and Configuration

The number of patches and their position in relation to each other, as well as the distance between them may have considerable effect on the micro-environments and their interactions within the landscape (Forman and Godron, 1981; Wilcove, 1985; Clark and Nudds, 1991). A number of patches in close proximity to each other could function as one entity (cluster), while patches further apart may suffer from the isolation effect, which hinders species gene flow and diversity.

2.4 Corridors

Corridors have been classified by height, width, pattern, and dynamics. Gates (1991) separates corridors into two structural types, convex and concave. Convex corridors have a greater height than the adjacent matrix, while concave corridors are characterized by a lower height. An example of a convex corridor would be a shelterbelt in a field, while a power line through a forested area would be considered concave.

Forman and Godron (1981) have defined four types of corridors; line corridors, strip corridors, stream corridors, and corridor networks. Line and strip corridors differ only in their width with the former being relatively thin, such as a shelterbelt, while the latter is wider. A transmission line would be an example of a strip corridor. Stream corridors are those which simply follow watercourses and vary in width. They are usually dendritic in pattern. When corridors intersect they form networks, which may include any combination of the other types.

Corridors serve different functions, depending on the type of corridor, type of habitat, and types of local wildlife (Forman, 1987). Gates (1991) states that the primary factors which determine a corridor's function include animal species or species assemblage, composition and structure of plant community within and adjacent to the corridor, the nature of the corridor-matrix edge, the size and shape of the corridor, and corridor position in relation to the other corridors. Gates further suggests that the primary forces determining the function of a *power line* corridor are animal species assemblage, the composition and structure of the corridor, the corridor matrix edge, and the composition of the adjacent habitat.

Corridors may function as specialized habitats, behavioral barriers, filters to wildlife movement, and as a source of effects on the matrix (Forman, 1987;

Gates, 1991). They may also provide travel lanes for animals between patches (Forman, 1987, Harris, 1988, Lines & Harris, 1989).

Corridors may have costs as well as potential benefits (Simberloff and Cox, 1987; Hobbs, 1992; Simberloff et al., 1992). Such costs could be physical, such as the transmission of diseases, fires, as well as increased exposure to predators, domestic animals, and hunters (poachers) or economical in nature. Simberloff and Cox (1987) use an example that a bridge, built to maintain a corridor, costs about thirteen times greater (per lane mile) than a road which would sever the corridor. They further suggest that it may be cheaper to move species between refuges than to buy and maintain corridors.

2.4.1 Specialized Habitats

A direct relationship appears to exist between corridor width and the development of an interior environment (Anderson et al, 1977; Johnson et al., 1979; Forman, 1982). Anderson et al. (1977) determined that narrow corridors (12 m) reduced bird species diversity while larger corridors (30.5 m) had both high bird densities and diversity. They further determined that wider corridors attracted several open-country bird species not characteristic of the surrounding matrix. Johnson et al. (1979) concluded that diversity of small mammals was highest in edge and right-of-way communities bordered by a forest matrix.

2.4.2 Barriers

A behavioral barrier occurs when movement of a particular species is normally concentrated within one of two adjacent habitat types, and animal movements pile up at the edge between the two types (Gates, 1991). Morgan and Gates (1983) determined that small and medium-sized mammals avoided crossing a dense grass corridor due to the physical difficulty in traversing it.

Forman and Godron (1981) indicate edge permeability increases as adjacent habitat contrasts decrease, thus by creating various vegetation succession levels the barrier effect may be minimized.

2.4.3 Filters

Corridors with different vegetation may act as behavioral filters (Forman, 1987). Animal activity is highest within their specific habitat type, lower on the edge, and lowest in the habitat not typical to that species. Gates (1991) suggests that choosing specific types of vegetation for a corridor and keeping that vegetation homogenous throughout the corridor may reduce the filter effect.

2.4.4 Travel Lanes

The use of corridors as travel lanes for animal species facilitates reintroduction of species into an area as well as increased gene flow (Forman, 1981). Increased activity of predator species along corridors have also been noted, due to a greater density and availability of prey (Gates & Glysel, 1978; Chasko & Gates, 1982; Forman, 1987). Wagner and Merriam (1979) suggest birds and small mammals use corridor edges because they represent the shortest distance between two points within a matrix, or that the corridor connects different resource patches.

2.5 Energy, Nutrient, and Species Fluxes

Forman and Godron (1981) state that fluxes of energy, mineral nutrients, and species occur between adjacent stands of habitat. The main fluxes between corridor-patch and corridor-matrix are species (Forman, 1982). Nutrients and other materials are moved by foraging animals from edge to forest or corridor or across to adjacent habitats (Gates, 1991).

Gates (1991) further suggests that if edges represent areas of greater animal concentration and activity, then high contrast, narrow, multi-layered edges may function as catalysts for biological activity, thus enhancing energy flow between patches.

2.6 Guidelines for Native Prairie Restoration

The principles and restoration methods, for the purpose of this study, will apply to both tall and mixed grass prairie. The steps and guidelines for native prairie restoration are the result of the work of a number of authors (Leskiw, 1978; McClain, 1986, et al.; Collicutt and Morgan, 1991).

2.6.1 Plant Species Selection

The selection of plant species to be used is thought to be critical to the ultimate success of a project. The two aspects of species selection which must be considered are the appropriateness of the species for the project in mind and the origin of the seed.

Restoration of truly authentic prairie must adhere to local floral records (Collicutt and Morgan, 1991). There is considerable diversity between southern and northern prairie (in North America), with the northernmost portion (Manitoba) considered "diversity poor". Soil and moisture regimes of the project must also be considered. Composition of the prairie has been found to vary with changes in soil and moisture (Weaver, 1954).

Seed origin must also be considered. Due to the difficulty of collecting local seed, usually because there is little parent prairie remaining, *cultivars* have been used as a substitute. Cultivars are semi-domesticated native grasses which have their origins in a specific ecotype, which is usually distinct from the local ecotype. Cultivar seeds are more readily available than locally produced seed, and can easily be purchased from U.S. suppliers. Experience has shown that growing cultivars too far from their place of origin can be detrimental to the long-term success of the project (Jacobson et al, 1986; Morgan, personal communication, 1992). If possible, it is preferred to use native seed grown locally to **a)** maximize the potential for success of the project and **b)** contribute to the preservation of the local ecotypes.

2.6.2 Seed Harvesting and Processing

Local seed is available from *Prairie Habitats*, a company specializing in the restoration of prairie in Manitoba. It should be noted that successful restoration of prairie will provide for a greater abundance of seed which, in turn, can be harvested for other restoration projects.

2.6.3 Site Preparation

The most important aspect of site preparation is controlling unwanted species, whose seeds are generally abundant in disturbed areas, such as cultivated fields. It has been determined that site preparation is location-specific, and that each site may require different types of preparation (Collicutt and Morgan, 1991). In the past, tillage was recommended to kill unwanted vegetation (Rock, 1981), however some now believe that the use of herbicides may be more advantageous, as the disturbance is then kept at a minimum (Armstrong, 1990).

2.6.4 Seeding

Sowing seed onto a prepared site, using a specialized native seed drill is considered the most effective means of restoring native prairie (Morgan, Personal Communication, 1992). The seed drill is "an implement, usually drawn by tractor, that ploughs small furrows into which it metres specified amounts of seed from a storage container through tubes that release the seed just at the ground surface. It possesses some mechanism, usually packer wheels, that fill the furrows in and compact the soil about the seeds". Not only does the drill accomplish the seeding in one operation, but because it deposits seed directly into the soil, it requires less seed than other methods (Rock, 1981; Bowen, 1990).

Recommended rates at which to sow seeds for restoration range from ten to twelve kilograms per hectare seeded (Collicutt and Morgan, 1991). The recommended time of year to sow a site is late spring or early summer (Leskiw, 1978; Rock, 1981).

2.6.5 Post Establishment Maintenance

Prior to any scientific testing of the sites, the prairie must be given a chance to take root. It is generally agreed that control of weeds during the first and second growing seasons is necessary, and should comprise the bulk of active involvement in the restoration (Collicutt and Morgan, 1991; Betz, 1986). Excessive competition by weed species with native prairie species can inhibit the seedlings growth rate. Standard treatments for annual or biennial weeds is repeated mowing or cutting (McClain, 1986), use of herbicides (Woehler, 1981), or cattle grazing (Berg, 1990).

2.6.6 Long-term Management

It is generally agreed that once native perennial are established at a site, burning is recommended. Fire not only removes dead plant material, but also kills actively growing weeds (Collicut and Morgan, 1991). Higgins et al (1989) believe that burning can be an effective controller of "cool season" grasses or other perennial unwanted species, and that multiple spring burns will weaken them while enhancing the vigour of the native species. Most prairie plants are able to survive burnings because they are resistant to fire or begin to grow later in the season (Hulbert, 1986). There is a historical argument for the use of fire as well, as it is generally agreed that it was prairie fires which deterred the encroachment of the aspen parkland on the prairie landscape.

A second long-term management tool may be controlled grazing or mowing, although this has been considered by few restorationists (Collicutt and Morgan, 1991). It is based on the premise that grazers such as bison and pronghorn antelope, which were plentiful prior to European arrival, played a significant role in controlling the ecosystem (Berg, 1990). In the event that burning is not possible, this management tool may be useful.

2.7 Adaptive Resource Management

In the past, there has been a basic dichotomy between "pure" research and applied resource management (specifically wildlife), in terms of theoretical framework construction, empirical data collection, and interpretation (Clark and

Nudds, 1992). Walters (1986) has identified two fundamental flaws in the early development of renewable resource sciences. The first is that research and management have concentrated primarily on biological/ecological and technical harvesting issues, and only lightly dealt with the socioeconomic dynamics that are never completely controlled by management activities. A second flaw is in how the sciences should address questions in a world of growing uncertainty, limited research resources, and continuing pressure for more exploitation. The traditional response was to invest more in basic research, in which a "better" understanding has been synonymous with a more detailed analysis. Science was left to the sciences and resource management to the managing agencies. In recent decades, however, it has become more apparent that scientists and resource managers could not continue pursuing goals and objectives in an isolated setting. The need for scientists and decision-makers to synthesize their efforts in resource management was recognized in the 1970's (Holling and Clark, 1975, Holling, 1978). With increased popularity of conservation biology (Soule, 1986) and **landscape ecology** (Forman and Godron, 1981) in the last two decades, similar goals and objectives have emerged: to reduce (remove) the gap between the pure and applied sciences (Clark and Nudds, 1992), and to reevaluate the relationship between scientists and resource managers.

The roles and objectives of resource managers and researchers have led to disagreement in the past in terms of information processing and decision-making (Nudds, 1992). Resource managers must often make decisions quickly, and have little time to reduce the uncertainty of various alternative management options. They take what information is given them and try to "make the best of it" in their decision making process. Researchers argue that more information is necessary before management can proceed. The problem is that both managers and researchers serve different functions in the resource framework, and while they may operate independently of each other, a symbiotic relationship does, in fact, exist between them. The resource manager is dependent upon the information provided by the researcher, while the researcher often requires funding or areas to perform experiments from the manager. Resource managers need to apply scientific methodology in their management techniques, while researchers use management perturbations as good scientific experiments to test their hypotheses (Sinclair, 1992). A greater interplay is necessary between resource managers and researchers than has traditionally been seen (Holling, 1978). The basic premise of adaptive resource management is that the separation of manager and researcher need not exist, and that "*there is no need to curtail management while research is conducted*" (Nudds, 1992). Researchers and managers can learn by doing (Walters and Holling, 1990; Nudds, 1992), using the project itself as an experimental probe (Walters and Hilborn, 1976).

The objective of adaptive resource management, then, is to develop

> "*a process where management itself becomes a partner with the science by designing probes that produce updated understanding as well as economic product*" (Walters and Holling, 1990;2060).

This concept is by no means novel, but has increased in popularity because of necessity. It is now realized that we live in an environment where action must be taken, unlike the past, however uncertain the outcome (Walters and Holling, 1990). It is further being understood that our knowledge of the environment is never complete, and the system is constantly changing with increased human impact. Adaptive management techniques must be developed which achieve *ever-changing understanding*, as well as the social goals desired (Walters and Holling, 1990).

2.7.1 Management structure

Walters (1986) has identified three methods of management structure as an adaptive process. These include 1) evolutionary, 2) passive adaptive, and 3) active adaptive.

Evolutionary

Evolutionary management occurs when choices are "haphazard" , while later choices are made from a subset and give better results.

Passive adaptive

Passive adaptive management involves using the best *available* data (historical) to determine a best estimate or response. The decision is based on the assumption that this model is correct. While passive adaptive models can result in informative experiments, two fundamental problems are associated with them. First, they are likely to confound management and environmental effects. Walters and Collie (1988) explain that debates are still occurring over the effects of fishing and environmental factors on fisheries with a long history of monitoring. Second, they fail to detect opportunities for improving systems which may have the right response due to the "wrong" model. Walters indicates that most theoretical literature on resource management is aimed at providing the single best prediction of policy choice, presupposing a passive adaptive strategy.

Active adaptive

Active adaptive management is where available data at each time are used to structure a range of alternative response models, and the policy choice reflects some computed balance between expected short-term performance and long-term value of knowing which alternative model (if any) is correct.

Walters and Holling (1990) identify a number of challenges which must be addressed in justifying and designing experimental management programs.

1. Demonstrate that a substantial, deliberate change in policy should even be considered, given the alternative of pretending certainty and waiting for nature to expose any gaps in understanding.
2. Expose uncertainties and management decision choices in a format that will promote both intelligent choice and a search for imaginative and safe experiment options, by using tools of statistical decision analysis.
3. Identify experimental designs that distinguish clearly between localized and large-scale effects, making the best possible use for opportunities for replication and comparison.
4. Develop designs that will permit unambiguous assessment of transient responses to policy changes, in the face of uncontrolled environmental factors that may affect treated and reference experimental units differently.
5. There is a need to set priorities for investments in research, management, and monitoring, and for design of institutional arrangements that will be in place for long enough to measure large-scale responses that may take several decades to unfold.

2.7.2 Adaptive resource management and prairie restoration

Due to the spacial and temporal characteristics of habitat restoration, adaptive management techniques could be adopted. Restorations can be both small or large-scale, and usually require considerable time to complete (if they are ever completed).

The literature provided little information about native grassland restoration projects which have, or are being, carried out in a scientific fashion in Canada (Collicutt and Morgan, 1990). An earlier project involving a tall grass prairie relict in Winnipeg involved some experiments which only lasted a year and yielded no significant data. If a large-scale restoration project were to be undertaken, the potential for adaptive resource management theory to be implemented is good.

Chapter 3. Methods

3.1 Overview of Methods

The overall goal of the research is to provide a planning framework for prairie restoration along rights-of-way. While this particular study focuses on power transmission lines, the methods and results may be applicable in other rights-of-way situations. The methods outlined provide a) a systematic approach to reduce a large study area into smaller, manageable units, b) a means to identify specific sites which may be suitable for prairie (or other habitat) restoration and patch connection, and c) viable testing procedures which may be used to evaluate restoration success.

3.2 Selection of Study Area and Study Zones

3.2.1 Study area criteria

The study area boundary was chosen on the basis of historical vegetation, current land use, and the number of transmission lines. The study area includes both tall and mixed grass prairie zones. It was important to select an area which did, at one time, contain prairie as its natural vegetation. Otherwise, the prairie species would be considered exotic (non-native) in relation to their surroundings. By definition, this could not be considered restoration. The area was also selected because it contained two types of prairie, tall grass and mixed grass. This would allow for direct comparison between the two types in the testing procedures, and provide a more comprehensive database.

The area was also chosen because of the varied, intensive agricultural practices within it. This has greatly reduced the natural prairie areas, allowing for greater restoration opportunities.

Another important criterion for selecting the study area was the amount of transmission line development within it. The area between Brandon and Winnipeg contains a considerable number of power lines. Additionally, future transmission line planning is currently under way. This provided for more right-of-way areas to be analyzed.

To more specifically define the study area, only areas with of marginal agricultural value were analyzed. Based on agricultural capability classifications provided by the Canada Land Inventory (1966), lands with classifications of 1, 2, and 7 were omitted while lands with classifications of 3, 4, 5, and 6 were selected as study zones. The Canada Land Inventory was used as a selection criteria because it classifies agricultural lands in great detail in terms of their potential productivity. Class 1 and 2 agricultural lands were excluded from the study, as it is currently uneconomical to use this land for non-agricultural purposes. They represent the most productive soils in the province. Class 7 lands were also excluded, as they inherently cannot sustain permanent vegetation. Classes 3, 4, 5, and 6 were included due to their marginal agricultural quality, making non-agricultural vegetation replacement along power lines a feasible alternative. Through exclusion of the class 1, 2, and 7 lands, the study area was divided into smaller sub-zones. It should be noted that the Land Inventory subclasses were not used to further define the study area, primarily because they would restrict the focus of the study too much. Additionally, only areas which are currently being farmed regardless of the subclass limitations were analyzed.

3.2.2 Study zone criteria

When choosing the study zones within the study area, three criteria were met. First, as outlined above, the study zones must be primarily composed of class 3, 4, 5, or 6 lands. Second, they must include transmission line corridors with a 100 foot (30 metre) right-of-way. Finally, the zones must be located where both tall and mixed grass prairie historically existed. It was also important to choose more than one zone from each prairie type. This allows for greater statistical comparison of data generated during the testing stage.

Once the soil capability information was delineated, six study zones were chosen. The zones were chosen arbitrarily, and all met the selection criteria. Their boundaries were chosen on the basis of townships and ranges, as this would allow for easier identification from aerial photographs, as well as being a quick reference system in Canada. The zones differed in size and shape, depending on the number and directions of the transmission lines within them.

3.3 Background Research of Study Zones

Once the study zones were defined, background research on each zone was completed. It was important to determine what types of vegetation occupied the lands prior to agricultural development, thus providing a rationale for true restoration. Primary information included a historical account of the area in terms of appearance and species composition, as described by early land survey reports which were completed when Manitoba was being settled (1870's). This information was available in the Manitoba Provincial Archives.

3.4 Identify Existing Power Lines Within Each Zone

All power lines within each study zone were identified on aerial photographs, using a stereoscope. The zones were divided into townships, with one aerial photograph representing one township (where possible). Transmission lines of 115 Kv or greater were mapped directly onto the aerial photograph (yellow line), as only the transmission line systems with 30 metre rights-of-way would be used. Any townships which did not contain power lines were omitted from the study.

3.5 Vegetation Survey

Upon completion of the power line identification within the study zones, identification of non-agricultural vegetation along the lines was completed. *Non-agricultural* vegetation includes all vegetation which is not subjected to intensive agricultural practices which would see the vegetation significantly altered over a short period of time. The survey was completed by physical evaluation and aerial photograph interpretation. The physical survey was conducted by driving through the study zones in the summer of 1992 (June, August). All vegetation along power lines, visible from the roads, as well as a general description of the area was noted. Aerial photograph examination took place in late summer and autumn, 1992. The aerial photographs and stereoscope needed for the survey were provided by Manitoba Hydro. The aerial photographs were taken in 1988. Vegetation which appeared to be in a relatively permanent state was considered in terms of its type, size, and proximity to the transmission line. This included grasslands used for grazing as well as any *long-term* agricultural operation (tree nursery, eg.).

3.5.1 Restoration criteria

All areas along the power lines were considered in terms of the potential to connect patches, the potential of connection with existing corridors, such as shelterbelts or highway right-of-ways, and the potential to restore native prairie vegetation where none currently exists.

Areas for patch connection (indicated by red on aerial photographs) were selected so patches of non-agricultural vegetation could be directly connected to transmission line rights-of-way, and were in relatively close proximity to each other. It was important that patches be directly connectable, to allow for maximum potential of migration of species. For some plant and animal species, 100 metres over an agricultural field may act as a complete barrier to dispersal (Mader, 1984, Saunders et al., 1991).

Prairie restoration areas (indicated by blue on the aerial photographs) were selected based on the potential for connection with other corridors, such as a shelterbelt system. This was not a limiting factor however, as any area along the right-of-way could offer potential.

It was important that all lands which would be used were currently being farmed, so that no permanent vegetation would have to be removed in favour of the restoration. All areas selected (patch connection and prairie restoration) satisfied this criterion.

Minimal disruption to farming practices was also a criterion. Only areas where a restoration project would cause minimal disruption to the normal farming practice (cultivating, combining, etc.) were selected. Generally, rights-of-way which passed between quarter sections or along their edges were chosen. The results of the vegetation survey are found in Appendix 7.

3.6 Experimentation

The literature provided little information about native grassland restoration projects which have, or are being, carried out in a scientific fashion in Canada (Collicutt and Morgan, 1990). An earlier project involving a tall grass prairie relict in Winnipeg involved some experiments which only lasted a year and yielded no significant data, therefore, prior to any large capital investment, adequate testing should completed to determine the potential success of prairie restoration along power lines. Through testing specific sites, each with different attributes, it may be possible to measure and compare the positive, negative, or neutral effects in relation to species migration and diversity. The tests should also determine the maintenance technique which would be most cost effective in a restoration project. Upon completion of the short-term experimentation, future tests could be designed which adhere to the concept of adaptive resource management.

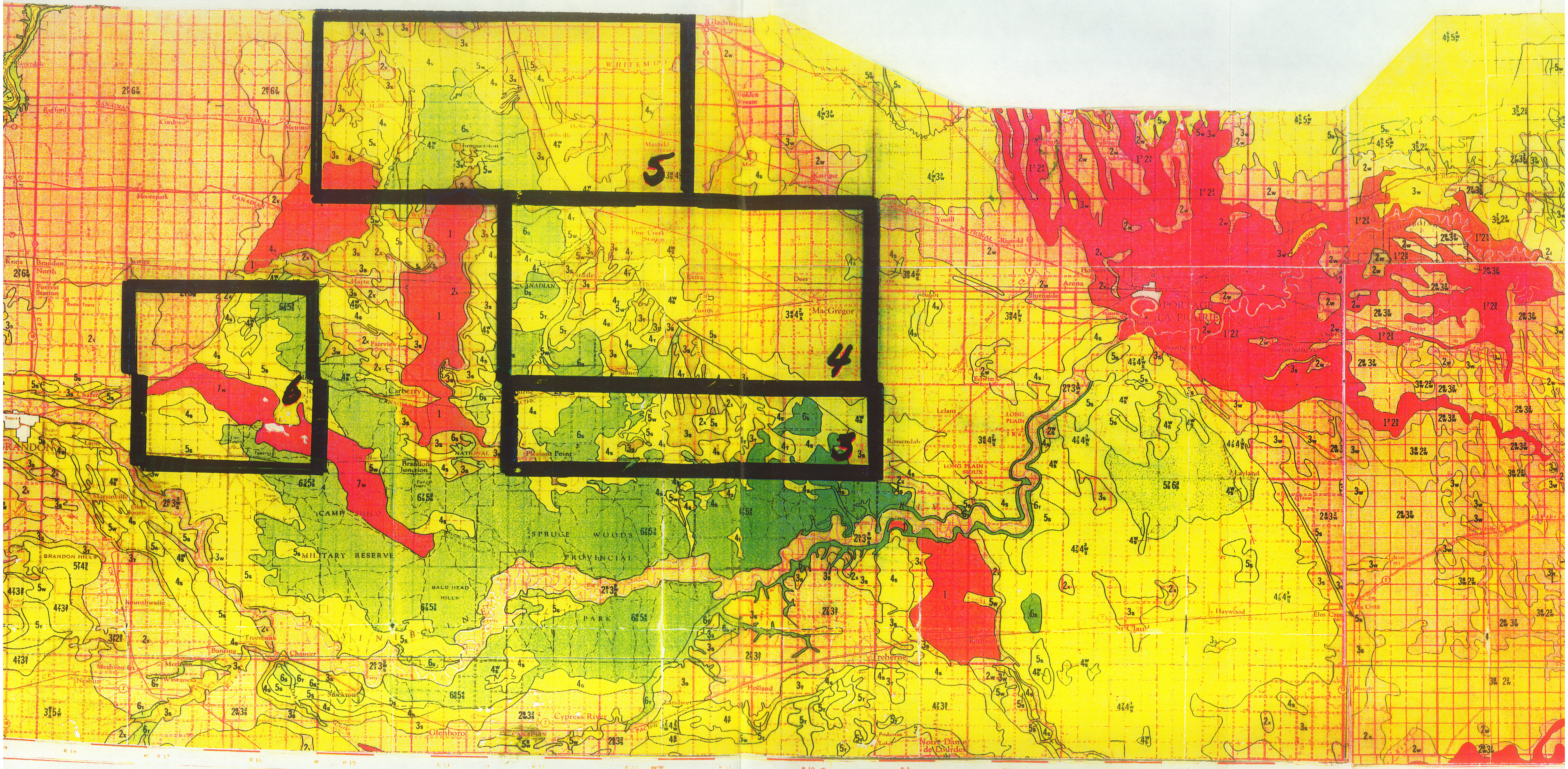
Chapter 4. Results

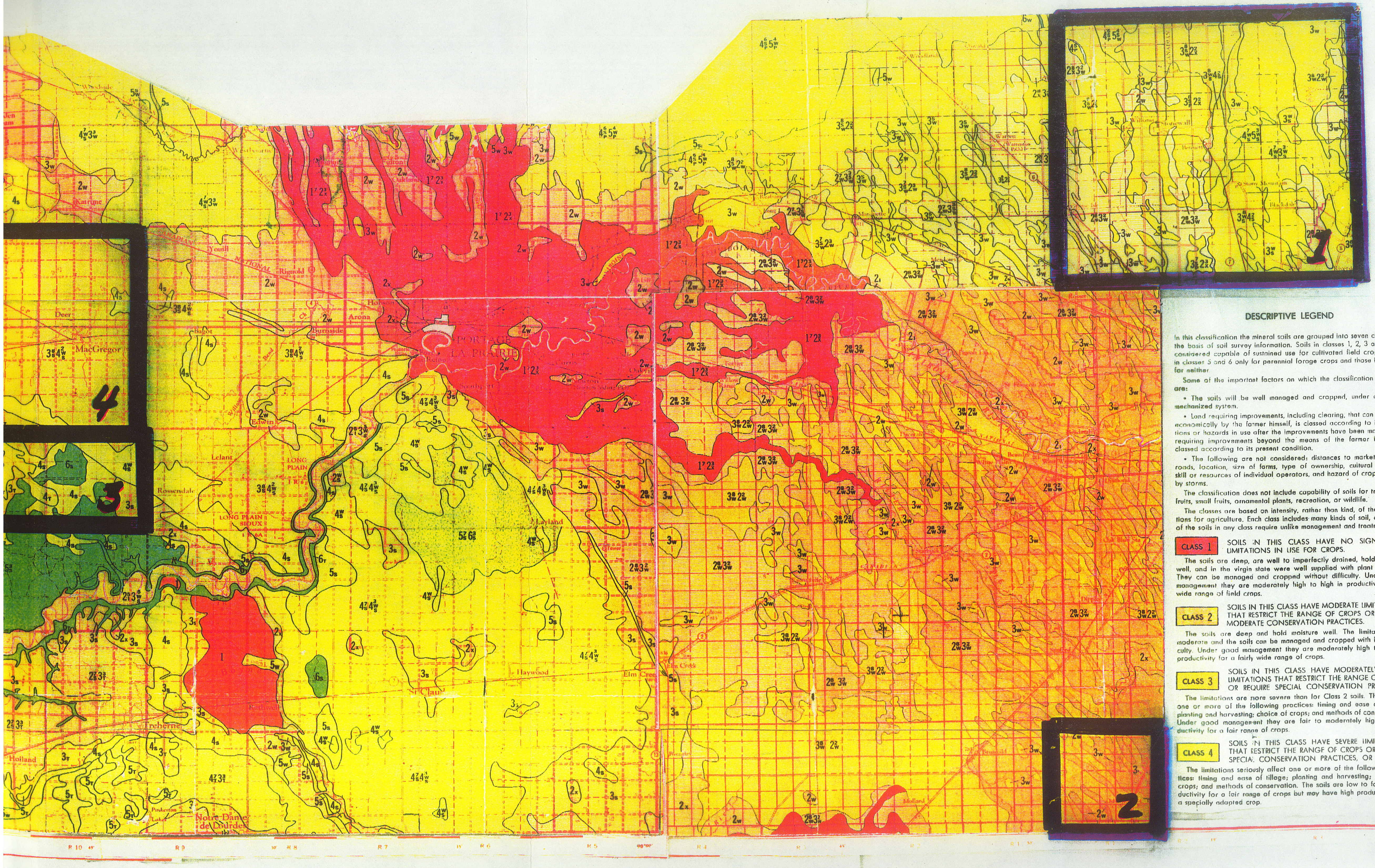
The results of this study are presented as the selected study zones, historical assessment of study zones, transmission line survey, patch connection, and native prairie restoration.

4.1 Selected study zones

The study zone boundaries were defined by townships and ranges and were chosen on the basis of historical prairie occupation, transmission line development, and Canada Land Inventory classifications of 3, 4, 5, and 6. The zones varied in area, primarily depending on the soil classifications. The soil classifications were found to be very detailed in nature, with many different classifications contained within any particular township. It was necessary to determine study zones which contained predominantly class 3, 4, 5, or 6 soils, although small patches of class 1 or 2 soils may also have been included. The study zones selected are identified in figure 8.

Figure 8. Selected Study Zones





DESCRIPTIVE LEGEND

In this classification the mineral soils are grouped into seven classes on the basis of soil survey information. Soils in classes 1, 2, 3 and 4 are considered capable of sustained use for cultivated field crops, those in classes 5 and 6 only for perennial forage crops and those in class 7 for neither.

Some of the important factors on which the classification is based are:

- The soils will be well managed and cropped, under a largely mechanized system.
- Land requiring improvements, including clearing, that can be made economically by the farmer himself, is classed according to its limitations or hazards in use after the improvements have been made. Land requiring improvements beyond the means of the farmer himself is classed according to its present condition.
- The following are not considered: distances to market, kind of roads, location, size of farms, type of ownership, cultural patterns, skill or resources of individual operators, and hazard of crop damage by storms.

The classification does not include capability of soils for trees, tree fruits, small fruits, ornamental plants, recreation, or wildlife.

The classes are based on intensity, rather than kind, of their limitations for agriculture. Each class includes many kinds of soil, and many of the soils in any class require unlike management and treatment.

CLASS 1 SOILS IN THIS CLASS HAVE NO SIGNIFICANT LIMITATIONS IN USE FOR CROPS.

The soils are deep, are well to imperfectly drained, hold moisture well, and in the virgin state were well supplied with plant nutrients. They can be managed and cropped without difficulty. Under good management they are moderately high to high in productivity for a wide range of field crops.

CLASS 2 SOILS IN THIS CLASS HAVE MODERATE LIMITATIONS THAT RESTRICT THE RANGE OF CROPS OR REQUIRE MODERATE CONSERVATION PRACTICES.

The soils are deep and hold moisture well. The limitations are moderate and the soils can be managed and cropped with little difficulty. Under good management they are moderately high to high in productivity for a fairly wide range of crops.

CLASS 3 SOILS IN THIS CLASS HAVE MODERATELY SEVERE LIMITATIONS THAT RESTRICT THE RANGE OF CROPS OR REQUIRE SPECIAL CONSERVATION PRACTICES.

The limitations are more severe than for Class 2 soils. They affect one or more of the following practices: timing and ease of tillage; planting and harvesting; choice of crops; and methods of conservation. Under good management they are fair to moderately high in productivity for a fair range of crops.

CLASS 4 SOILS IN THIS CLASS HAVE SEVERE LIMITATIONS THAT RESTRICT THE RANGE OF CROPS OR REQUIRE SPECIAL CONSERVATION PRACTICES, OR BOTH.

The limitations seriously affect one or more of the following practices: timing and ease of tillage; planting and harvesting; choice of crops; and methods of conservation. The soils are low to fair in productivity for a fair range of crops but may have high productivity for a specially adapted crop.

CLASS 5 SOILS IN THIS CLASS HAVE VERY SEVERE LIMITATIONS THAT RESTRICT THEIR CAPABILITY TO PRODUCING PERENNIAL FORAGE CROPS, AND IMPROVEMENT PRACTICES ARE FEASIBLE.

The limitations are so severe that the soils are not capable of use for sustained production of annual field crops. The soils are capable of producing native or tame species of perennial forage plants, and may be improved by use of farm machinery. The improvement practices may include clearing of bush, cultivation, seeding, fertilizing, or water control.

CLASS 6 SOILS IN THIS CLASS ARE CAPABLE ONLY OF PRODUCING PERENNIAL FORAGE CROPS, AND IMPROVEMENT PRACTICES ARE NOT FEASIBLE.

The soils provide some sustained grazing for farm animals, but the limitations are so severe that improvement by use of farm machinery is impractical. The terrain may be unsuitable for use of farm machinery, or the soils may not respond to improvement, or the grazing season may be very short.

CLASS 7 SOILS IN THIS CLASS HAVE NO CAPABILITY FOR ARABLE CULTURE OR PERMANENT PASTURE.

This class also includes rockland, other non-soil areas, and bodies of water too small to show on the maps.

0 ORGANIC SOILS (Not placed in capability classes)

SUBCLASSES

Excepting Class 1, the classes are divided into subclasses on the basis of kinds of limitation. The subclasses are as follows:

* SUBCLASS C: adverse climate — The main limitation is low temperature or low or poor distribution of rainfall during the cropping season, or a combination of these.

* SUBCLASS E: erosion damage — Past damage from erosion limits agricultural use of the land.

SUBCLASS I: inundation — Flooding by streams or lakes limits agricultural use.

SUBCLASS P: stoniness — Stones interfere with tillage, planting, and harvesting.

SUBCLASS R: shallowness to solid bedrock — Solid bedrock is less than three feet from the surface.

SUBCLASS S: soil limitations — Limitations include one or more of the following undesirable structure, low permeability, a restricted rooting zone because of soil characteristics, low natural fertility, low moisture-holding capacity, salinity.

SUBCLASS T: adverse topography — Either steepness or the pattern of slopes limits agricultural use.

SUBCLASS W: excess water — Excess water other than from flooding limits use for agriculture. The excess water may be due to poor drainage, a high water table, seepage or runoff from surrounding areas.

SUBCLASS X: Soils having a moderate limitation caused by the cumulative effect of two or more adverse characteristics which singly are not serious enough to affect the class rating.

CONVENTIONS

Large arabic numerals denote capability classes.
Small arabic numerals placed after a class numeral give the approximate proportion of the class out of a total of 10. Letters placed after class numerals denote the subclasses, i.e. limitations.

*Denotes class or subclass not present on this map

EXAMPLES

An area of Class 4 land with topography and stoniness limitations is shown thus: 4^{T}_{P}

An area of Class 2 with topographic limitation, and Class 4 with stoniness limitation, in the proportions of 7:3 is shown thus: $2^{7}_{T}4^{3}_{P}$

N.B. The color used for a complex area is determined by the first digit of the symbol. Generally the dominant class appears first in a complex symbol. However, in complexes of two arable classes (1-4) and one non arable class (5-7), the arable classes are shown first if they total one half or more of the map unit.

This pattern is overprinted on the color in complex areas, except those having ratios of 8:2, 8:1:1 and 9:1.

4.2 Historical assessment of study zones

The study area is situated within the historical boundaries of the aspen parkland, which contained both grassland and forested areas. It was necessary to further determine the historical vegetation of the areas which the transmission lines actually pass through. The results of this investigation provided historical rationale for native prairie restoration along the transmission lines.

4.2.1 Study Zone 1

Geographical location: *Townships* 12, 13, 14 *Ranges* 1, 2, 3
East of the 1st meridian

Total sections: 288

Soil capability: Predominantly class 3.

Study zone 1 lies north of Winnipeg, and is characterized by agricultural lands with relatively few vegetation patches. Some forested areas are found on the western boundary of the zone, but the area is predominantly devoid of non-agricultural vegetation. The zone has a number of transmission lines running through it, particularly four 115 Kv lines and one 230 Kv line.

J. Lestock Reid surveyed the area on May 31, 1872. It was noted that this area contained both **"open prairie"** and **"wet marshes"** with a average water depth of three feet. Unfortunately, government surveyors, at that time, were more concerned about the soil and less about the vegetation. For this reason, some surveyors were more descriptive than others.

4.2.2 Study Zone 2

Geographical location: *Township* 7 *Range* 1

West of the 1st meridian

Total sections: 36

Soil capability: Predominantly class 3

Study zone 2 falls within the area which has historically been dominated by tall-grass prairie. The zone is heavily farmed with wheat and sunflowers appearing to be the favoured crops. The only patches of vegetation visible from the roads appear to surround farm residences. One 115 Kv transmission line runs north-south through the zone.

This zone was surveyed on July 31, 1972, by J.B. Richard. No tree species were recorded by Richard in the area. He described the entire area as "excellent soil and fine prairie land". He also described the prairie as "beautiful".

4.2.3 Study Zone 3

Geographical location: *Townships* 10 *Ranges* 10, 11, 12, 13

West of the 1st meridian

Total sections: 432

Soil capability: Predominantly class 6. Some class 3, 4, 5

Study zone 3, southwest of Portage La Prairie, differs greatly from zones 1 and 2 as the topography is much more pronounced, and the soil is very sandy. Farming and cattle grazing are evident in the north and southeast parts of the zone while Spruce Woods Provincial Park encompasses the greater portion. There is much more non-agricultural vegetation, particularly along the Assiniboine River. There are relatively many patches of non-agricultural vegetation north of the park. One 230 Kv transmission line runs east-west through the zone.

J.L. Reid surveyed this area on September 10, 1872, and noted a number of different vegetation types. The area where the power line currently passes is described as follows:

Sections 1-6.	Open prairie with scattered oak, willow, and sand ridges;
Sections 7-12.	Open prairie with scattered oak, willow, and sand ridges;
Sections 13-18.	Prairie with scattered oak, poplar, scrub and sand ridges;
Sections 19-24.	Open prairie with sand ridges;
Sections 25-30.	Open prairie with scrub and sand hills;

Sections 31-36. Ash, elm, and poplar swamp. High sand ridges with scrub.

4.2.4 Study Zone 4

Geographical location: *Townships* 11, 12 *Ranges* 10, 11, 12, 13 **West** of the 1st meridian

Total sections: 288

Soil capability: Classes 3, 4, 5, 6

Study zone 4 lies just north of SZ 3. The relief in this zone is more gentle, with fewer hills in the north. Many non-agricultural vegetation patches are found in this zone. One 115 Kv transmission line transects the zone running east-west.

A.C. Webb surveyed this area on June 21, 1872. The area where the power line passes is described as follows:

Sections 1-6 "These pembina are very rough and irregular with sandy soil. Unfit for farming. Oak, poplar, and other scrub. Heavy poplar, birch, elm, ash, with dense hazel, willow, and scrub (sec. 6)";

Sections 7-12 "Land very low and swampy (sec. 7). Thick poplar and other woods, with willow, hazel, and other dense bottom scrub";

Sections 13-18	"Poplar bluffs with dense willow and other scrub. Some prairie mixed with poplar and willow";
Sections 19-24	"Rolling prairie with poplar bluffs and low scrub. Some dense willow patches";
Sections 25-30	"Rolling prairie with low willow scrub. Some swamp";
Sections 31-36	"Rolling prairie with willow scrub".

4.2.5 Study Zone 5

Geographical location: *Townships* 13, 14 *Ranges* 12, 13, 14, 15
West of the 1st meridian

Total sections: 288

Soil capability: Predominantly class 3. Some class 4, 5, 6

Study zone 5 is more heavily forested than the previous zones, with relatively fewer non-agricultural vegetation patches. The landscape is more continuous forest with agricultural fields intermixed. In contrast to the previous zones, more land appears to be dedicated to cattle grazing rather than farming. Two 115 Kv transmission lines run through the zone.

The area was surveyed by H. Le Ber on July 5, 1873. The description is as follows:

Sections 1-6	"Oak, poplars, and hazel brush. Undulating surface".
Sections 7-12	"Poplars, cherry, hazel. Tall willows. Undulating surface".

Sections 13-18 "Tall scattered poplars. Tall willows. Poplar, oak, hazel brush. Undulating surface".

Sections 19-24 "Tall, green poplars. Few dry and scattered trees. Hay marsh. Hazel brush".

Sections 25-30 "Scattered green and dry poplars. Downfallen woods and tall weeds".

Sections 31-36 "Scattered oak and poplar. Small poplars. Few oak. Prairie".

It is important to note that only in the northernmost sections of the area is there any reference to prairie. It is this area where the transmission lines run.

4.2.6 Study Zone 6

Geographical location: *Townships* 9, 10, 11 *Ranges* 16, 17
West of the 1st meridian

Total Sections: 216

Soil capability: Classes 4, 5, 6

Study zone 6 is located in the most westerly portion of the study area. Current land use indicates a mixture of farming and grazing land. Few non-agricultural vegetation patches were found, except surrounding farmyards. This appears to be consistent with the observations of A.C. Webb and J. Doupe when they surveyed the area on June 17, 1873 (north) and October 17, 1873 (south) respectively. Webb described the entire northern portion as "rolling prairie with poplar bluffs", while Doupe simply described the southern portion as "undulating prairie". One 230 Kv transmission line runs through the zone.

4.3 Transmission line survey

Upon completion of the field survey, the study zones were examined further using aerial photographs. Once the study zones were determined (on the photographs), transmission lines were identified and mapped (yellow). Using a stereoscope, rights-of-way were analyzed in terms of patch connection, which was indicated by red, and prairie restoration, indicated by blue. The results of the transmission line survey are presented in appendix 7. Table 1 summarizes the results.

Table 1

Summary Table - Prairie restoration and patch connection possibilities

Study Zone	Prairie Restoration		Patch Connection	
	acre	hectare	acre	hectare
1	172	69.7	18	7.3
2	43	17.5	0	0
3	51	20.6	73	29.5
4	97	39.3	13	5.3
5	312	126.4	27	10.9
6	50	20.2	3	1.2
Totals	**725**	**293.62**	**134**	**54.3**

4.3.1 Patch connection

It was noted that patch abundance varied greatly between study zones. Study zones 4 and 5 contained large forested areas, while areas 1, 2, 3, and 6 contained relatively small areas.

While vegetation patch roles in landscape ecology occupy considerable space in the academic literature, little empirical research as to the effects of patch connection is available. It is hypothesized that the connection of patches with a habitat corridor would benefit wildlife species, however no empirical testing has been completed to support or oppose this view. Upon completion of the survey, possible test sites were sought. Ideally, a test site would have a small (less than a half acre), isolated patch in a cultivated field, which is between 50 to 100 metres away from a larger patch (larger than five acres), with a transmission line passing in close proximity to each (within 30 metres). Problems were encountered, however, when test site selection was attempted. These included a) number of patches, b) size of patches, c) proximity of patches to other patches, and d) proximity of patches to rights-of-way.

Number of patches

In simplest terms, the study zones either provided too many or two few patches. Study zone 5 contained the most number of patches, while study zones 1, 2, and 6 were almost entirely comprised of cultivated land. Opportunity existed for patch connection, particularly in study zones 3 and 5, however it would be extremely difficult to test whether these connections improved habitat quality.

Size of patches

Patch size was also a limiting factor in the selection of test sites. For the tests to remain simple (workable), the patches would have to be relatively small (a half acre or less). Patches within the study zones were generally too large to be able to design an experiment which could control for most factors.

Proximity of patches to other patches

Proximity of patches in relation to other patches was another limiting factor in test site identification. Preferred experimental sites would have isolated patches, which were not close enough to interact with other patches, but were close enough to connect via a transmission line corridor for testing.

It was found, however, that most patches were a considerable distance from each other, making test connection extremely expensive.

Proximity of patches to rights-of-way

While some study zones did have patches which met the other criteria, these patches were not near any transmission line rights-of-way, eliminating them from further consideration.

In terms of the objective, there are sites within the study area which may be used to connect vegetation patches, but due to the limiting factors outlined, test sites could not be chosen.

4.3.2 Prairie restoration

The survey indicates that there is considerable land available for native prairie restoration along transmission line corridors. All of the restoration areas identified met the selection criteria of potential to connect with other corridors and minimal disruption to existing farming practices. In regards to the second criteria, this is a limiting factor for this study only, and if arrangements could be made with the farmer, other areas not identified could be restored as well.

As with patch connection, little is known about success rates of native prairie restoration projects, as well as what effect these projects have on plants, wildlife, and the landscape in general. Until evidence supports otherwise, it is generally agreed that more habitat is good, and that corridor connection could enhance wildlife movement and possibly improve species diversity. In light of adaptive resource management theory, to design experiments for native prairie restoration *at the outset of the project* would allow for continual analysis and learning while applying practical management strategies.

Once all restoration areas were selected, statistical tests were designed. The goal was to design a powerful statistical test which could be replicated and could yield the most data, in both the short and long-term. It was determined that a "split plot" test would be suitable for this analysis (Kenkel, personal communication, 1992). The pilot study, once designed, was inspected by the University of Manitoba Statistical Advisory Committee.

The tests designed were required to satisfy two criteria. First, the experiments must apply to all test sites, in that results from each site can be compared, statistically, against the others. The second condition is that the tests remain relatively simple, as it has been shown that more complex experiments must often be simplified over time (Morgan, personal communication, 1992). The results of the initial tests will provide the basis for a planning framework, which may be integrated with current and future transmission line planning and maintenance.

Chapter 5. Experimentation

5.1 Proposed pilot study

The need for more thorough research in relation to habitat restoration has been stressed by a number of authors (Forman, 1986; Maurer, 1986; Clark and Nudds, 1991). Adequate testing should be completed to determine the potential success of prairie restoration along power lines, prior to any large capital investment. Through testing specific sites, each with different attributes, it may be possible to measure and compare the positive, negative, or neutral effects in relation to species migration and diversity. The tests should also determine the maintenance technique which would be most cost effective in a restoration project. Specific objectives of the pilot study are to:

1. determine the effect that non-native species have on native species in a competitive setting (tall and mixed grass);
2. determine the maintenance method which produces the most successful restoration of tall and mixed grass prairie (if any);
3. determine and evaluate the differences in restoration success between tall and mixed grass prairie (growth rates, etc.);
4. provide a comparison of restoration success in relation to project costs;
5. produce valuable data which is currently lacking in Canada.

5.1.1 Selection of test plots.

Six plots were selected (randomly) in each of study zones 1, 2, 4, and 5. Study zones 1 and 2 will be planted with tall grass prairie species, while study zones 4 and 5 will be planted with mixed grass. *Study zones 3 and 6 were eliminated from the proposed testing procedure.* Only two mixed grass zones could be used in the experiments in conjunction with the two tall grass zones, to allow for equal representation in comparative statistical analysis. In relation to the other two mixed grass zones, study zones 3 and 6 offered less potential for restoration and were eliminated.

All areas along power lines which were determined feasible for prairie restoration were divided into 65 metre parcels, and assigned a number. Numbers were then drawn randomly and six test plots were chosen per study zone. Of the six plots per study area, three were chosen which will be planted adjacent to existing road corridors, and three were chosen as "islands" in an agricultural field. This would allow for comparison of rates of non-native species intrusion between test plots. Each plot will be 30 metres x 65 metres in area (.2 ha). All test plots are represented by Figures 9-16b.

Figure 9

Aerial Photograph - Study zone 1
Township 12, Range 1, East of 1st.

Blue = Prairie restoration = 62 acres (25 ha)
Red = Patch connection
Yellow = Transmission line

Figure 10

TEST PLOT LOCATIONS
STUDY ZONE 1

TWP. 12 RGE. 1E

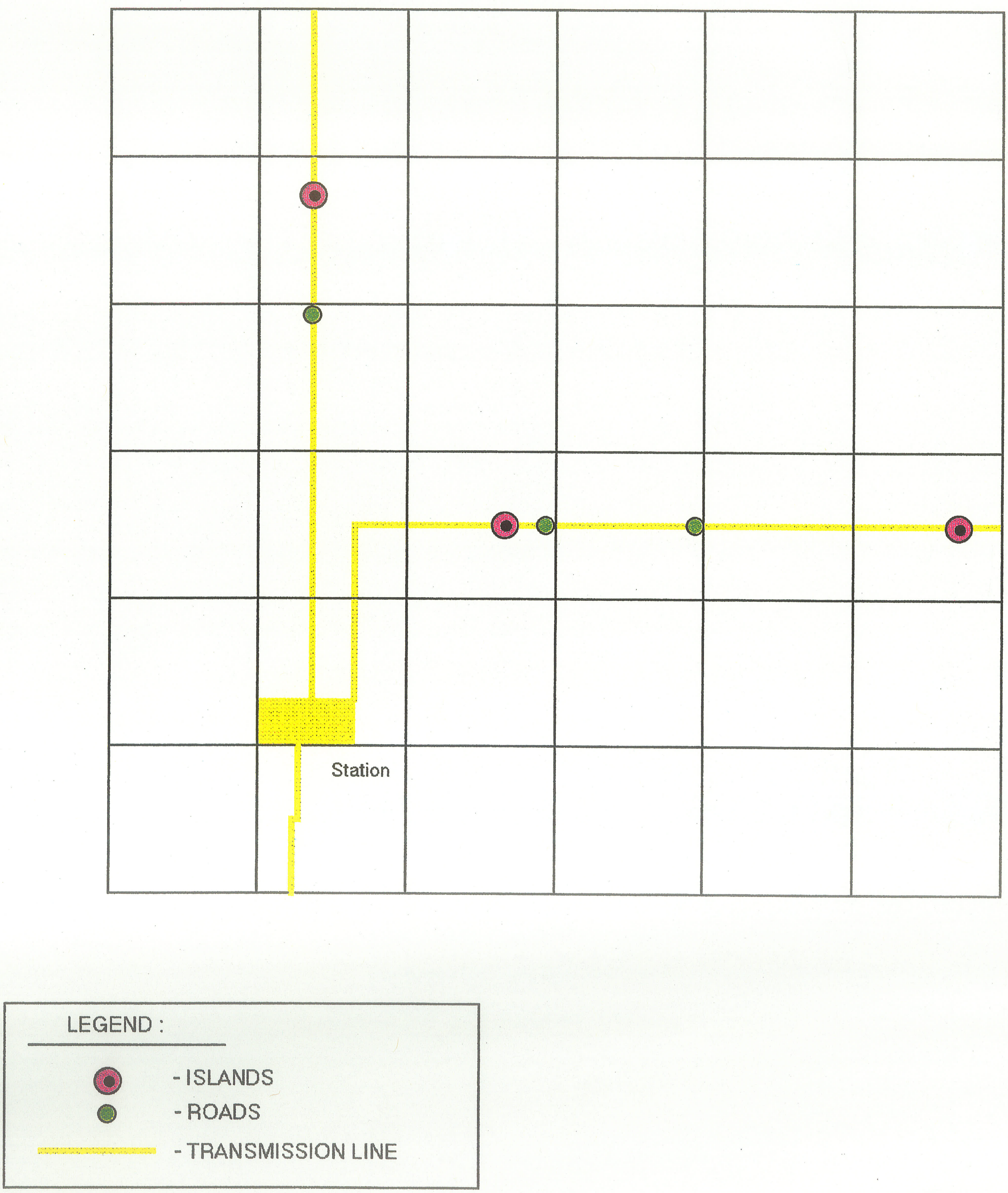
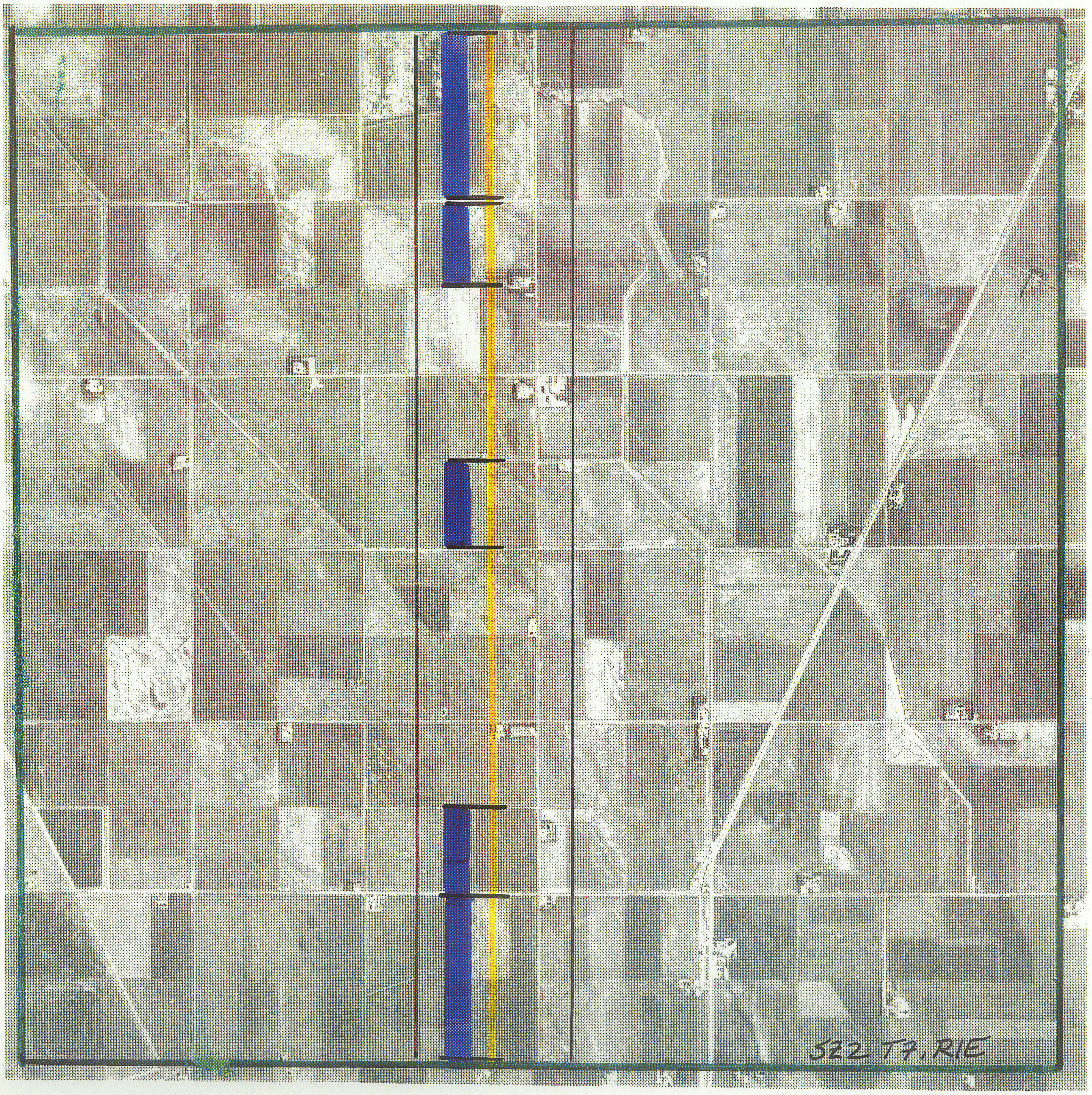


Figure 11

Aerial Photograph - Study zone 2
Township 7, Range 1, East of 1st.

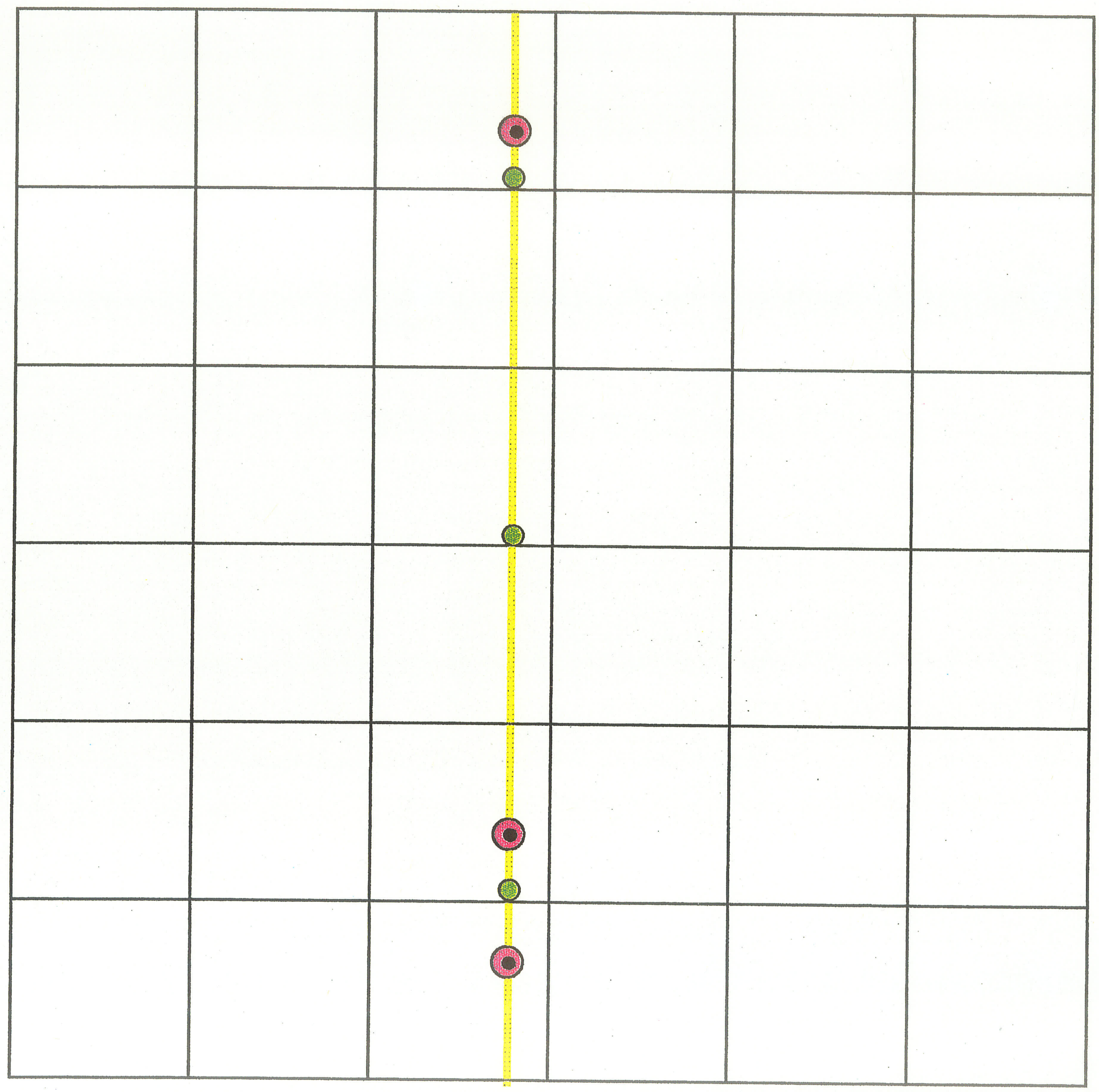


Blue = Prairie restoration = 43 acres (17.5 ha)
Red = Patch connection
Yellow = Transmission line

Figure 12

TEST PLOT LOCATIONS
STUDY ZONE 2

TWP. 7 RGE. 1E

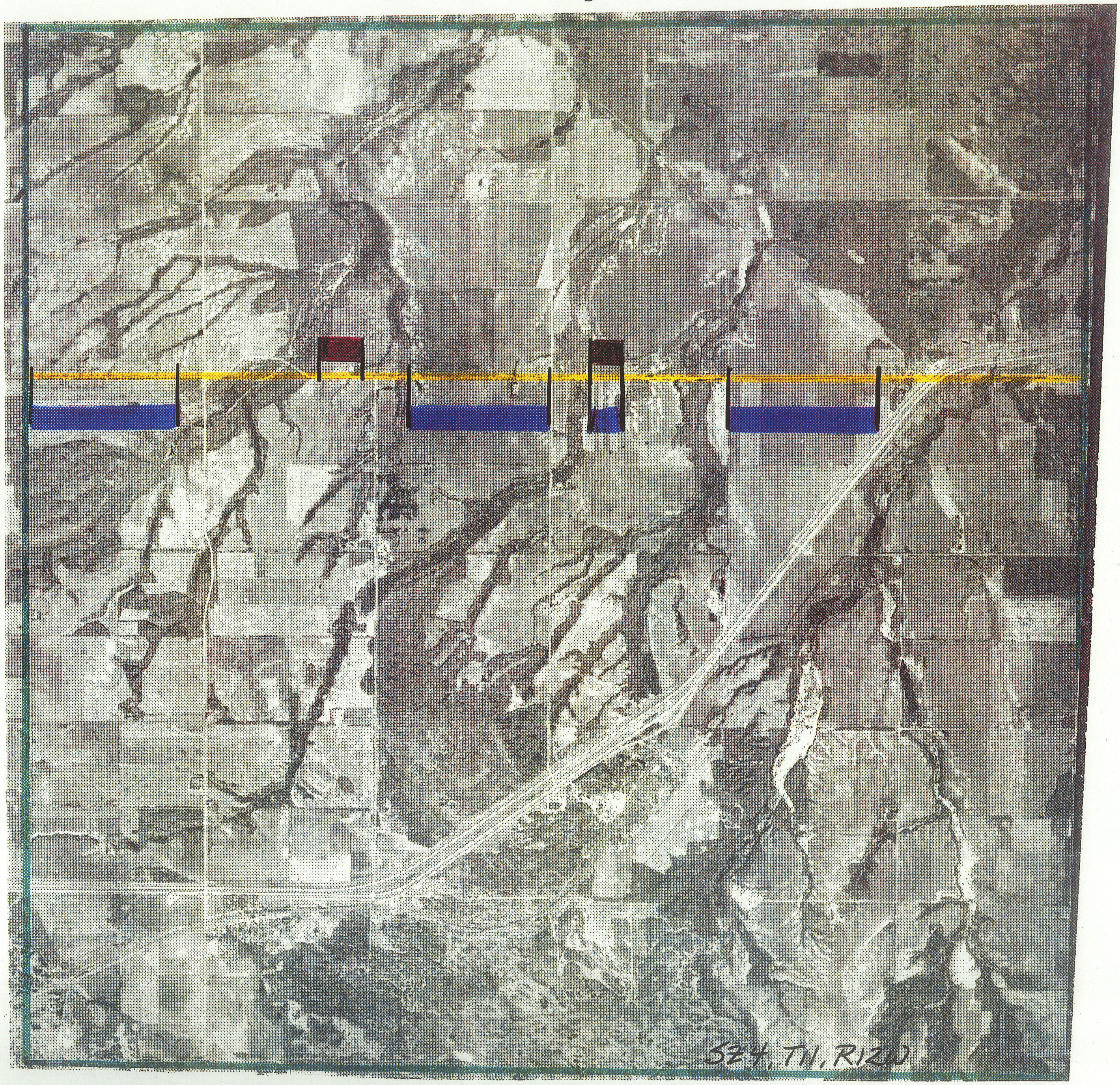


LEGEND :

- ISLANDS
- ROADS
- TRANSMISSION LINE

Figure 13

Aerial Photograph - Study zone 4
Township 11, Range 12, West of 1st.



Blue = Prairie restoration = 33 acres (13.4 ha)
Red = Patch connection = 6 acres (2.4 ha)
Yellow = Transmission line

Figure 14

TEST PLOT LOCATIONS
STUDY ZONE 4

TWP. 11 RGE. 12W

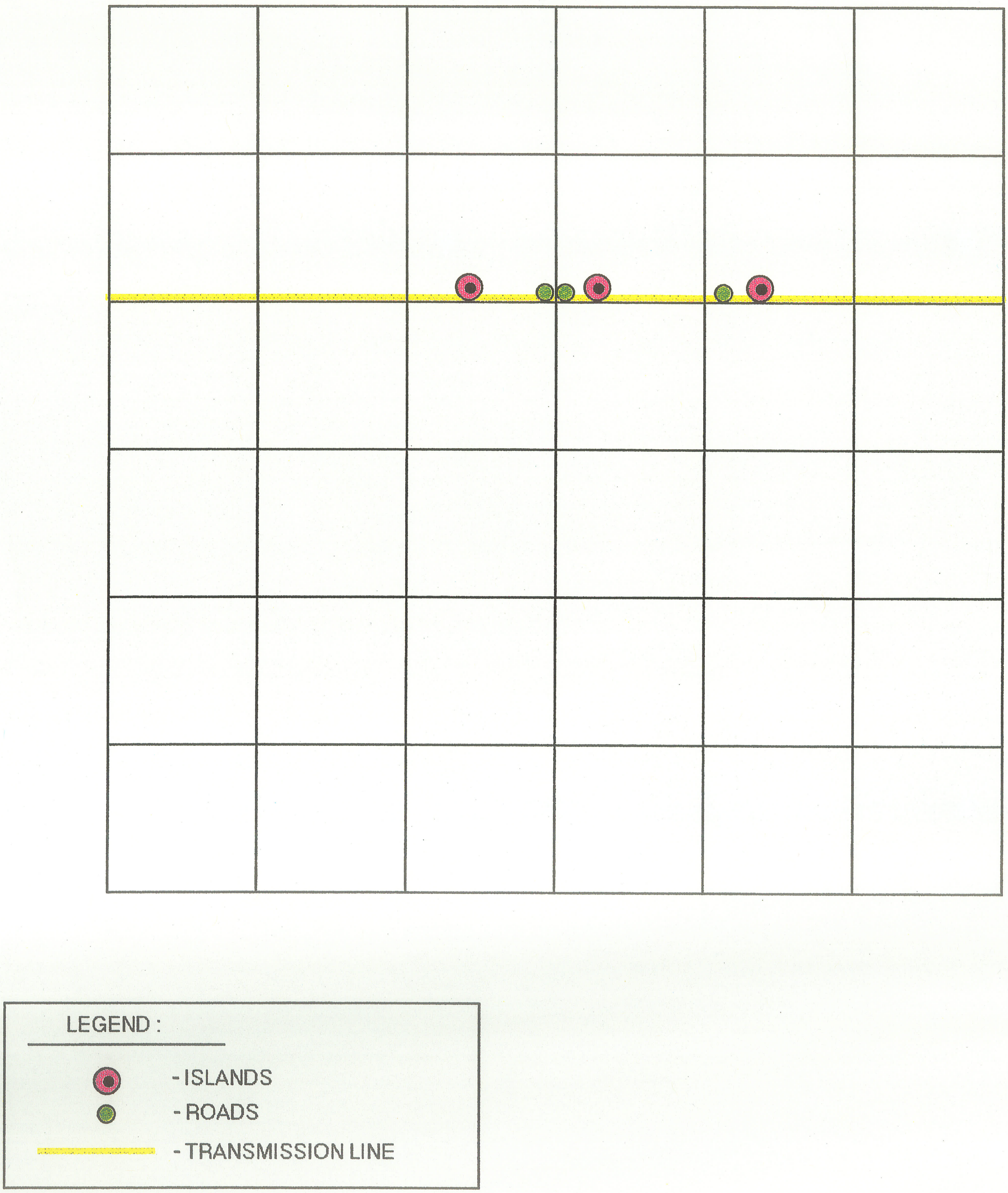
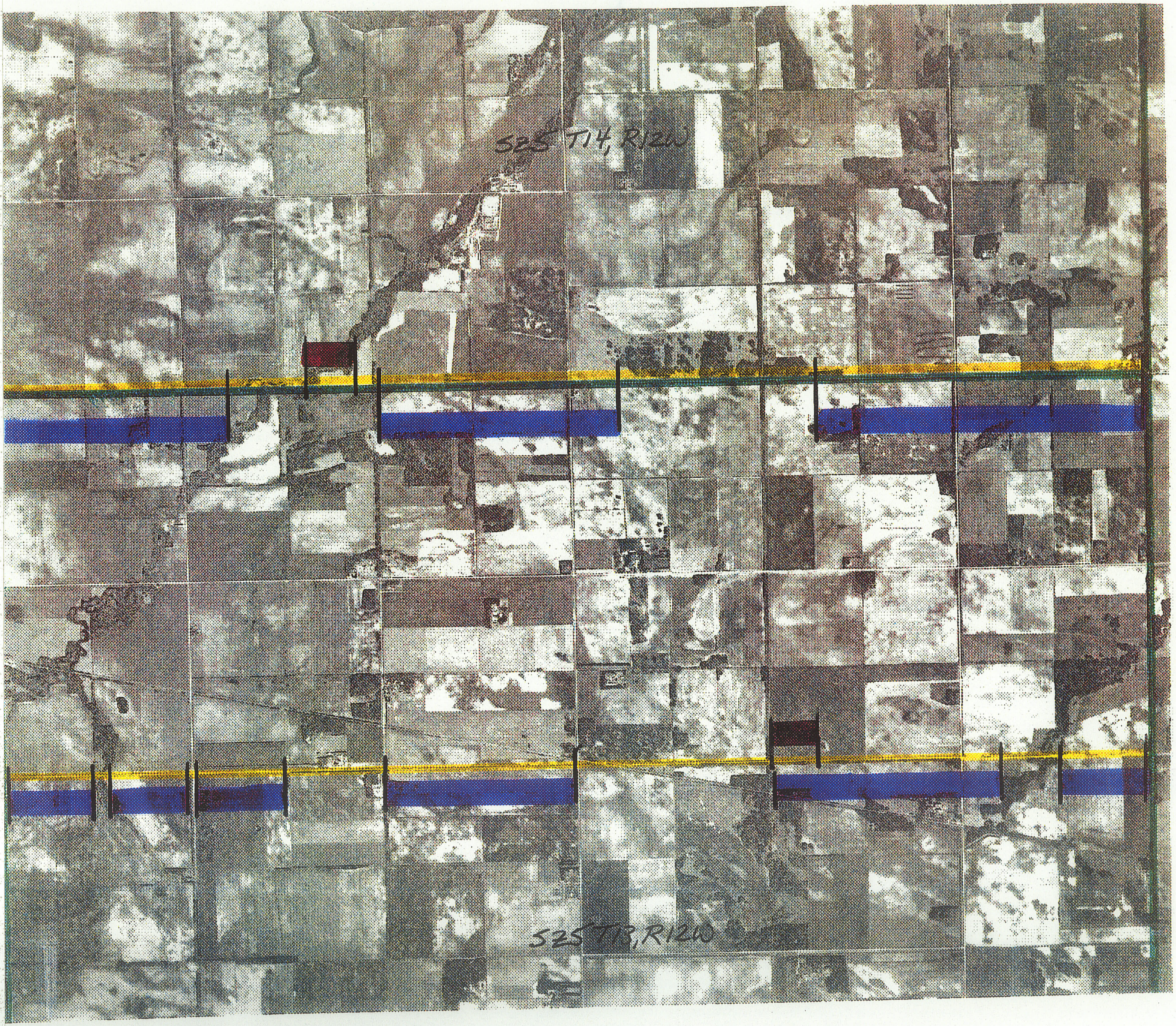


Figure 15

Aerial Photograph - Study zone 5
Township 13, Range 12, West of 1st.
Township 14, Range 12, West of 1st.

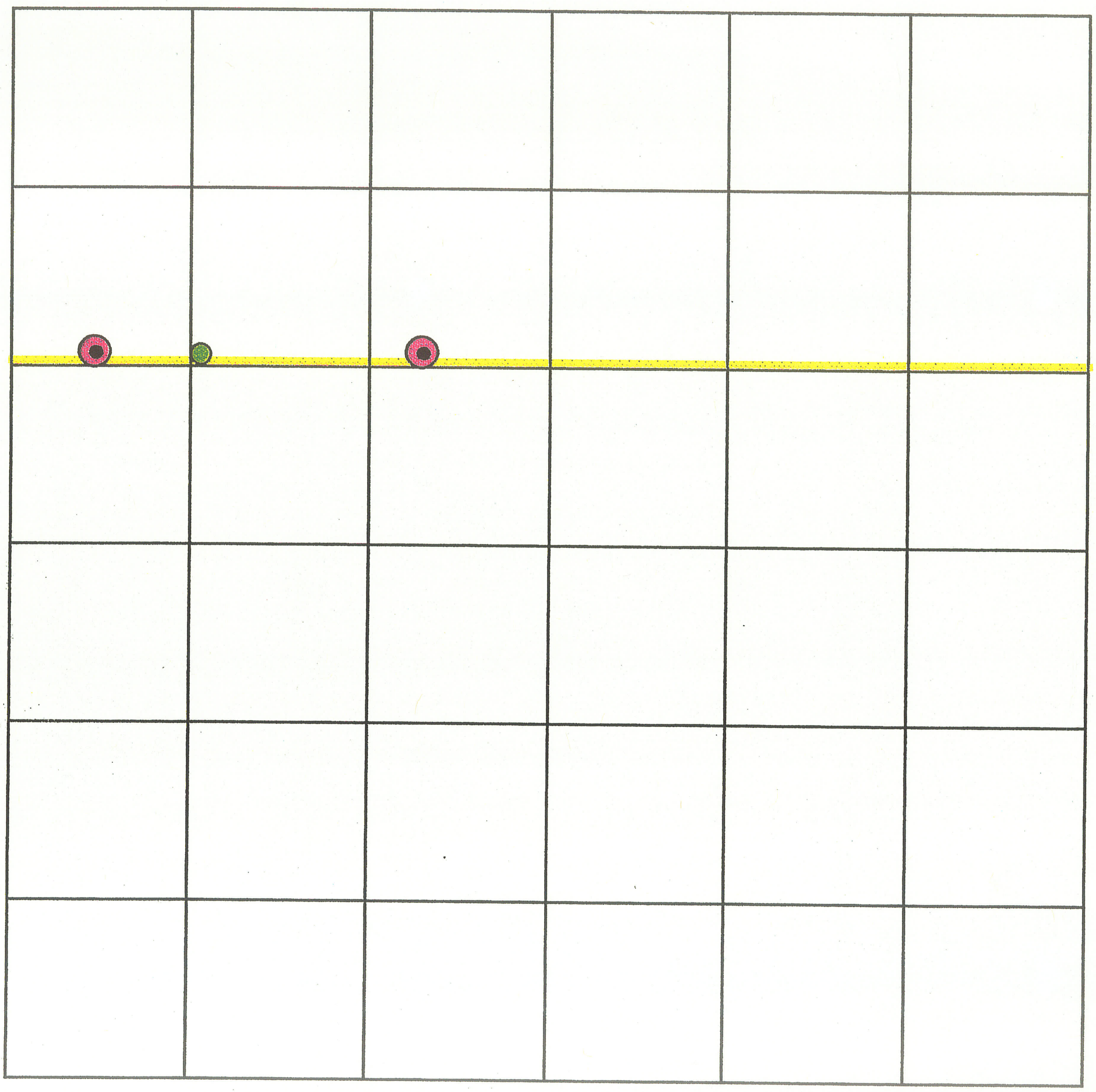


Blue = Prairie restoration = 100 acres (40.5 ha)
Red = Patch connection = 6 acres (2.4 ha)
Yellow = Transmission line

Figure 16 a

TEST PLOT LOCATIONS
STUDY ZONE 5

TWP. 13 RGE. 12W



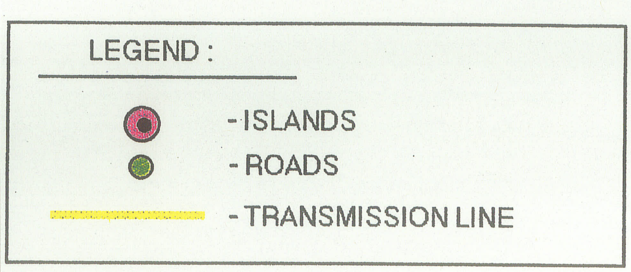
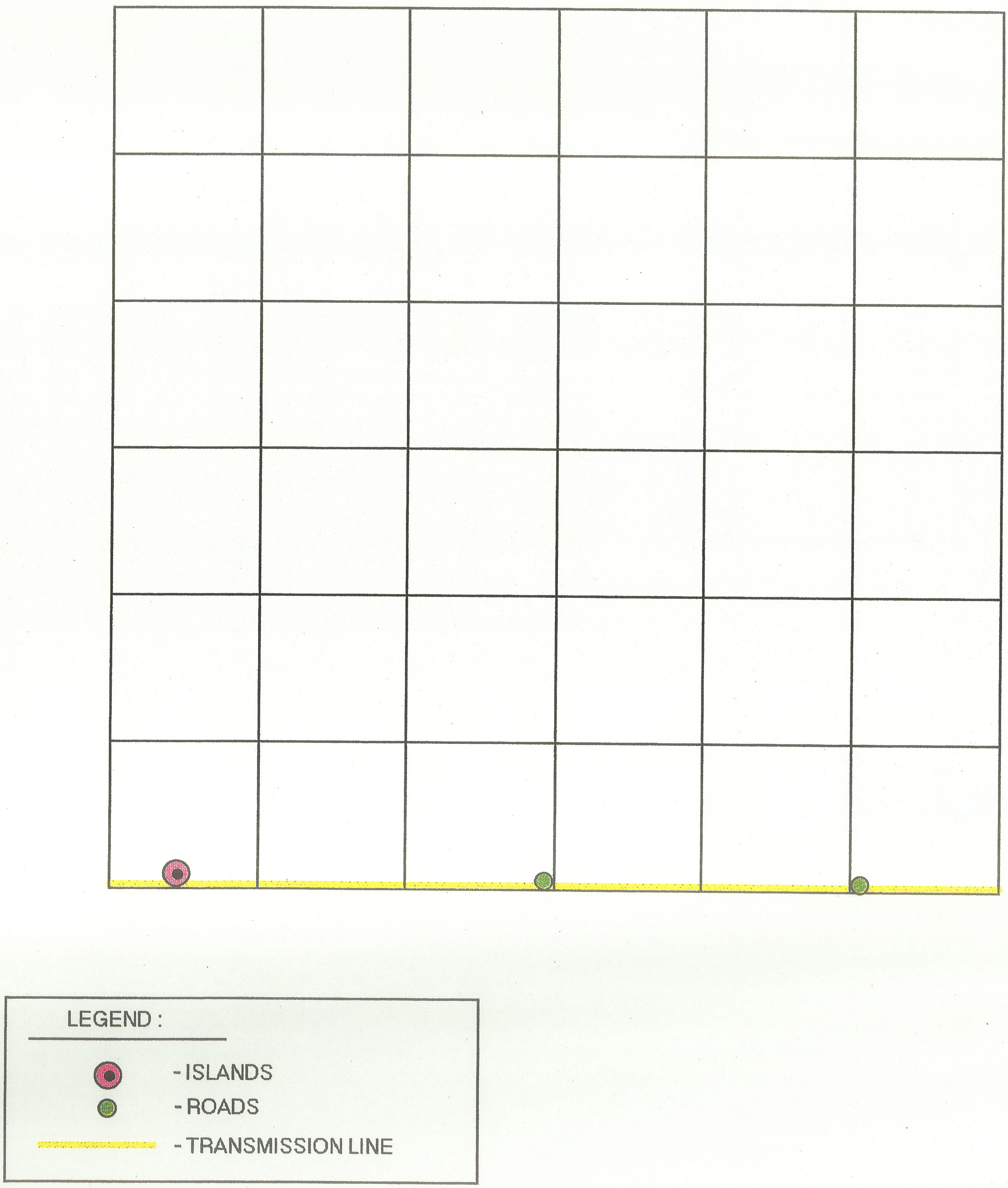


Figure 16 b

TEST PLOT LOCATIONS
STUDY ZONE 5

TWP. 14 RGE. 12W



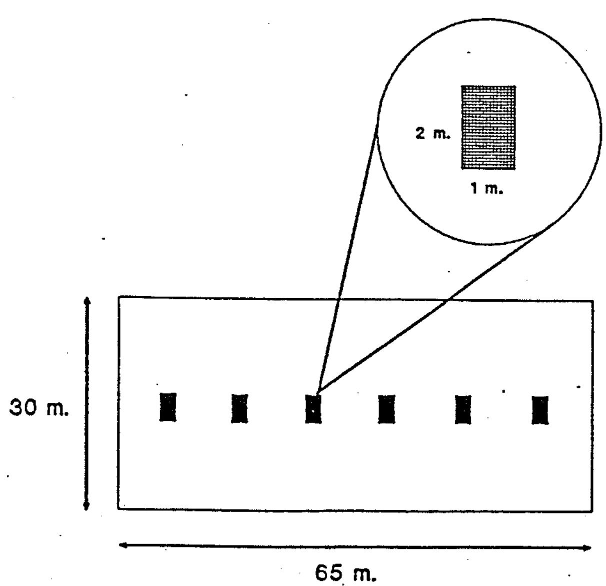
5.1.2 Seeding plots

Seeding will commence in late spring (May). It is usual practice to select specific seed mixes for specific areas (Morgan, personal communication, 1992). It is necessary however, for the purpose of this research, to use identical seed mixes for both tall grass and mixed grass zones. This is to control variation in the results due to the seed mix.

5.1.3 Establish permanent sub-plots

Comparative analysis of sub-plots will also be undertaken, for the purpose of determining any variation within each plot. Internal testing will determine directions and speed of non-native plant migrations. These sub-plots will transect the plot lengthwise, and will be permanently marked with coloured spikes. They will be one metre x two metres in dimension, and will be placed ten metres apart (Figure 17).

Figure 17



5.1.4 Initial weed control

It has been determined that weed control is very important during the early stages of restoration (Rock,1981), as excessive competition from annual and biennial weeds can impede the slower growing prairie seedlings (Wilson, 1970). Treatment will include repeated mowing or cutting to 5-8 cm in height. It is considered important to cut weeds before they flower and reseed. If necessary, spot herbiciding may also be implemented.

5.1.5 Management

Once the vegetation has become relatively well established (approx. 3 years), different maintenance methods will be implemented, to determine which methods provide the best final results. In each study zone one "island" plot will be mowed, one will be burned, and one will have zero maintenance (control plot). The same will occur for the plots adjacent to road corridors. Prescribed burnings (for the burning plots) will take place from March to May, and will occur annually. Mowing times will correspond to burnings.

5.1.6 Analysis

Specific observations will be noted throughout the first five steps, particularly weather and wind conditions, monthly precipitation levels, farming practices near plots, and types of crops grown near plots. Soil samples will be taken prior to seeding.

Directly prior to the first burning or mowing, plant species samples will be randomly selected (collected) within the sub-plots. This will continue over three growing seasons, resulting in 576 samples (6 per sub-plot x 6 plots x 4 study zones x 4 years).

There will be four basic variable levels which can be tested including sub-plot, plot, zone, and time.

Sub-plot

The data collected within the sub-plots will provide the basis for all subsequent levels of statistical analysis. Investigation on this level will include trends in non-native species migration and native species composition within the plot.

Plot

Trends derived from the sub-plot analysis can then be compared between plots. These tests will determine which plots are most successful in relation to others within the zone. At this level of examination, it will be possible to determine which maintenance types are preferable, as well as if connection to other corridors is possible.

Zone

Once the plot analysis is completed, it will be possible to compare the zone performance (tall grass versus mixed grass). This will determine if methods which appear successful for tall grass also are preferable in a mixed grass setting (and vice versa). Growth rate comparison can also be undertaken.

5.1.7 Statistical Tests

The procedures designed are similar to the "split plot" method of statistical sampling. Data collected will allow for the application of *analysis of variance* (ANOVA) tests. Also, *multivariate analysis* will be possible (species composition versus cost, eg.). These analyses can also be graphed, visualizing trends (linear or quadratic). These tests are considered very "powerful" statistically, and should provide significant results (Armstrong, personal communication, 1992).

Data collected will include vegetation samples from each sub-plot within the study plots. Types and frequency of the species will be recorded.

5.1.8 Faunal Analysis

Faunal observations should be undertaken in conjunction with the prairie (floral) testing. Valuable data can be gathered as to which species occupy the plots first, at what time periods (stages of growth) do species establish themselves. It will also be possible to determine how the maintenance practices affect the fauna within a plot. Information can be found using a variety of standard faunal data gathering techniques such as small mammal traps, nets (birds), or by direct researcher observation.

Once again, plots and zones can be statistically analyzed using ANOVA. As well, all species noted should be listed on a "checklist". The return of species normally indigenous to either tall grass or mixed grass prairie is desired. Indicator bird species of the Manitoba grasslands include:

Western meadowlark (*Sturnella negleta*)

Sprague's pipit (*Anthus spagueii*)

Savannah sparrow (*Passerculus sandwichensis*)

Grasshopper sparrow (*Ammodramus savannarum*)

Upland sandpiper (*Bartramia longicauda*)

Vesper sparrow (*Pooecetef gramineus*)

Clay-colored sparrow (*Spizella pallida*)

Baird's sparrow (*Ammodramus bairdii*)

(Wilson and Belcher, 1989).

Mammal species include:

White-tailed jack rabbit (*Lepus townsendii*)

Richardson's ground squirrel (*Spermophilus richardsonii*)

Thirteen-lined ground squirrel (*Spermophilus tridecemlineatus*)

Plains pocket gopher (*Perognathus flavescens*) (tallgrass)

Prairie vole (*Microtus ochrogaster*) (tallgrass)

Plains harvest mouse (*Reithrodontomys montanus*)

(Dubois, personal communication, 1992).

Chapter 6. Discussion

6.1 Costs

The cost of planting one acre of tall or mixed grass prairie in Manitoba is $2,000.00 (Morgan, personal communication, 1992). Maintenance for two years, prior to the first burning, will include mowing at a cost of $45.00/hr. The average time needed to mow one acre is three hours, and it is recommended that the plots be mowed at least three times per year. A preliminary cost schedule has been completed, which includes initial planting and maintenance for two years (Appendix 3).

6.2 Project Participation

The importance of partnerships and integrated management of fragmented landscapes, particularly in relation to the prairies, is recognized on both the federal and provincial level (Government of Canada, 1991; Government of Manitoba, 1991). The significance of landowner stewardship is also stressed. This trend follows the basic premise that a) the environment includes many stakeholders, b) development does produce externalities, c) these externalities must be addressed, and d) integrated decision-making and cooperation between interested agencies and individuals may produce a more thorough and comprehensive means to manage the resource.

This project has the *potential* to include a wide range of people and organizations which may contribute to it academically, economically, and physically. This follows a growing trend which encourages many users of a resource to actively participate in its management. These include university researchers, agriculturalists, non-government organizations, government agencies, and the public at large. A preliminary list of organizations which, potentially, may be interested in partnerships is provided (Appendix 4).

There are restoration efforts under way which emphasize partnership and coordination in Manitoba. Manitoba Prairie **CARE**, for example, under the direction of the Manitoba Habitat Heritage Corporation, offers landowners a wide range of conservation options to improve and protect wildlife habitat. The program is delivered by Ducks Unlimited Canada. Options to landowners include: incentives for farming practices which improve habitat; land lease or purchase for habitat development or protection; and support for conservation promotion. Additionally, the Manitoba Department of Highways and Transportation is working with both university and private researchers to restore native tall grass prairie along highway rights-of-way (Durant, 1993).

6.2.1 Universities

While restoration projects have been undertaken for many years in Canada, little empirical data is available in the literature, and many questions remain. The data compiled through this project will be invaluable for both present and future research, and the results will provide much clearer insight for restorationists in future projects. The project is multidisciplinary in nature, and while the tests are primarily botanical and zoological, there is potential for the inclusion of other disciplines, such as the earth sciences.

6.2.2 Agriculturalists

The farming sector should be encouraged to take an active interest in the project. Land use changes in favour of conservation practices have been adopted by many farmers in southern Manitoba and in many cases, depending on the form of compensation coupled with reduced operating costs, these farmers have seen a positive change in their net farm income (Josephson, 1992). It is important to consider the opportunity costs of the farmer to set aside land for conservation practices. Belcher (1991) indicated that current incentives for farmers to take land out of production for habitat enhancement are poor. For the initial test plots, compensation should be made to the farmers whose land the plots are planted. Since the plots will be half an acre in size, payment to farmers should be based on the price of the particular crop they are growing times the average yield per acre times the amount of land restored.

It has also been recognized that there are associated costs to farmers for having obstacles in their fields (Desjardins, 1983; Accutrak Systems, 1991). In a study commissioned by the North American Wildlife Foundation, it was determined that an obstacle with an area of 2000 square metres would cost 24 dollars per year to drive around (Accutrak Systems, 1991). The test plots would have an area of 1950 square metres (30 x 65) so this figure would be appropriate.

The farmers should also be fully informed as to what it is that the project is trying to accomplish. This would include a detailed description of all procedures and secondary benefits which the farmer may incur (reduced soil erosion, etc.). While the project is limited to rights-of-way, farmers should be encouraged to preserve and protect other grasslands and non-agricultural vegetation patches which may already exist on their land.

6.2.3 Non-government organizations

Non-government organizations (NGO's) may play an active role in the project. This may be in the form of technical expertise, financial assistance, or manpower. In some cases, NGO's working on current projects may be able to integrate them with the project. In many cases, the limiting factors for NGO projects are lack of funding or available lands. If transmission line rights-of-way were available for restoration more projects may be possible. By dividing restoration responsibilities, reduced costs per partner could result.

6.2.4 Government agencies

This project allows for partnerships to develop between agencies at all three levels of government (municipal, provincial, and federal). The Manitoba

Department of Highways and Transportation, for example, is evaluating the feasibility of restoring tall grass prairie along their rights-of-way (Durant, 1992). From a landscape ecology perspective, the connection of highway and transmission line corridors could greatly improve migration of species through increased corridor network capacity.

Through integration and cooperation between rights-of-way managers and government agencies, future projects will be able to transcend the boundaries of transmission line corridors, encompassing more areas which are also in need of restoration. Again, cooperation could be in the form of technical expertise, financial support, or manpower.

6.2.5 Public

If possible, every effort should be made to include the public in the project. The public has become increasingly aware and concerned about environmental issues and, as in the case of river cleanups, tree plantings, etc., are now participating in a variety of projects. This project could give the public valuable insight into program development, current research, problems encountered, as well as the day-to-day operations of the company. Signs posted at the test sites could explain about the project, as well as provide an open invitation to all interested parties to contact a project representative if further information is required. Participation could also be encouraged through school field trips, media advertising, or by mail (enclosed in billing envelopes).

6.3 Advantages of Prairie Restoration

There are several advantages to restoring native grass prairie (or any habitat) along rights-of-way (Forman and Godron, 1981; Leskiw, 1978). These include reduced use of herbicides, increased habitat for wildlife, preservation of rare plant communities, reduced soil erosion, and a general reduction of rights-of-way maintenance costs.

6.3.1 Reduced use of herbicides

As environmental concern over the use of herbicides grows, alternative vegetation management techniques are being considered. Elongated root systems, which are a characteristic of native grasses, tend to hold earth in place (Wilson, 1970). When established, native prairie forms a dense sod, which inhibits the capability of slower growing non-native tree species to take root. This greatly reduces the necessity of herbicides or cutting. The prairie is resilient enough to withstand vehicle traffic, so it would also withstand (or even aid) maintenance traffic along the rights-of-way.

6.3.2 Increased wildlife habitat

This research has shown that some areas in southern Manitoba are almost devoid of any wildlife habitat. The return of native prairie would not only provide habitat to an array of wildlife, it would also allow for greater movement of wildlife between areas (Forman, 1987). This may allow species to return to areas from which they have been eliminated. The prairies will also provide extra protection for smaller animals, and additional forage to larger species (Leskiw, 1978).

6.3.3 Preservation of rare plant communities

Tall grass prairie is extremely rare in Manitoba. Any effort to restore and preserve this unique plant community should be encouraged. Mixed grass prairie, although more plentiful, is also considered in relatively poor shape, in terms of area and species composition (Morgan, personal communication, 1992). Restoring these communities along rights-of-way serves two critical functions. First, species ***native*** to southern Manitoba are preserved. Second, these restored areas will provide seed for future restoration projects, reducing the need for non-native cultivars. This will ensure that not only will Manitoba continue to have prairie, but it will continue to have *it's* prairie.

6.3.4 Agricultural benefits

Shelterbelts are considered a valuable tool for reducing soil erosion (O'Grady, 1990; Sutton, 1983). Short term agricultural benefits include: reduction in damage to young seedlings by windblown soil particles; reduction in lodging; reduction of blowing out of newly seeded crops; and reduction of windblown swaths (Sutton, 1983). In the long term, shelterbelts aid in sustaining soil productivity by protecting the soil from wind erosion (O'Grady, 1990). Native prairie, established along transmission lines, could provide similar protection to soils, by reducing wind velocities. Reduced wind allows for greater moisture retention and less soil erosion. This is extremely beneficial, particularly to farmers. It has also been determined that grasslands enhance soil properties, due to rapid build-up of organic matter (Hole and Nielson, 1970).

6.3.5 Reduced maintenance costs

Once the native prairie is established, reduced maintenance along the transmission lines is expected. Because native species provide a stable community, they eliminate the need for constant and costly vegetation management by physical or chemical means (Leskiw, 1978). Costs incurred will be limited to the prescribed maintenance of the prairie (burning or mowing) (Appendix 2).

6.4 Potential problems associated with restoration

While native prairie restoration offers numerous potential benefits, problems may also be encountered. These include the possibility of damage from herbicides used on adjacent fields, hunting on restored prairies, and increased bird wire strikes.

6.4.1 Herbicides on adjacent fields

There is a possibility that damage may occur to the test plots due to farmers applying herbicides to the adjacent lands. During their application, herbicides may drift into the test plots. While some broadleaf herbicides may not damage native prairie grasses, the potential does exist, depending on the mixture (Morrison, personal communication, 1993). This problem may be mitigated by:

1. Making an agreement with the farmer, ensuring careful application of herbicides around the test plots;
2. No herbicide spraying directly around test plots;
3. Keeping a semi-permanent, cultivated border around the test plots;
4. Allow weeds to grow around the test plots, to create a barrier from herbicides (this, however, may result in more stringent monitoring and maintenance of the plots against the weed species).

It is important to note that while herbicide drift is a potential (unwanted) phenomenon, if it does occur the information will still be of great value. As with the other data collected, the effect of normal farming practices on native prairie restoration must be more fully understood if a larger-scale project is to be undertaken.

6.4.2 Hunting

In forested regions, transmission line rights-of-way may increase hunting pressure due to easier access to the areas. In agricultural regions however, the rights-of-way may serve a different purpose. There is a possibility that a restored strip of native prairie could attract hunters while, in search of bird and game species, may find greater opportunity along a right-of-way. Since the rights-of-way will be in the middle of cultivated fields (hunting usually begins after harvest) game species would have only the 30 metre strip of prairie as cover. This would be relatively easy to hunt, either flushing the game out into the open field immediately, or by "driving" the game to the end of the corridor, in which case there is no option for the species except to flush. Potential impacts in such a case would not be limited to game species, but all wildlife within the corridor.

Before any mitigating actions take place, land ownership must be determined. Current hunting regulations (in Manitoba) state that hunting along transmission line rights-of-way is allowed on Crown lands. Since the basis of this project is the restoration of prairie on currently farmed fields no Crown land is involved. On privately owned lands, hunters must first get permission from the landowner. An agreement should be made with the landowner to not allow hunting along the corridor, at least while the testing is still under way. After the testing, different arrangements may be negotiated, depending on the situation.

6.4.3 Wire strikes by birds

A potential problem of restoring native prairie directly underneath a transmission line is that higher incidence of birds colliding with wires (bird strikes) may result, due to them being attracted to the new habitat. Mortality may occur from either physical impact with the wires or by electrocution.

Manitoba Hydro (1992) has identified many factors which affect the risk of collision. These include bird biology factors, flight factors, transmission line factors, and environmental factors (Table 3).

It is unknown whether prairie restoration along the lines will contribute to increased incidence of bird strikes in southern Manitoba. Any occurrence of bird strikes should be recorded during the testing stage, as this information will be valuable during the evaluation process.

Table 2. Factors Affecting Bird Strikes

(from Manitoba Hydro, 1992;17)

General Category	Factor	Suspected High Collision Risk Situation
Bird Biology	Species Age Health Migration Sex	Nocturnal fliers, awkward flight characteristics Immature birds Sick or injured birds Migrants as opposed to residents Birds involved in nuptial displays
Flight	Flight intensity Altitude Size of Flocks Time of Flight	Large numbers crossing ROWs Lower than uppermost wires Large flock with small spacing between birds Nocturnal or diurnal flights during inclement weather
Transmission line	Tower type Voltage Conductor number of lines Overhead ground Line length Age of line Lights	Guyed structures, tall towers at river crossing Lower voltage line Small diameter single conductor Double circuit lines with wires at different heights Multiple wires with small diameter Long line running through high-use area Newly constructed lines before birds can habituate to it Non-flashing lights on towers in established flyways
Environment	Weather Habitat Human activity Location	Fog, snow, rain, sleet, high winds Attractive habitat on or surrounding ROW Hunting, other activities which startle birds Lines located perpendicular to narrow, low altitude flyways

6.5 Planning framework

The results of the pilot study should provide the information necessary to determine if native prairie restoration is a feasible management tool for transmission line rights-of-way in southern Manitoba. Two basic result scenarios exist, each of which could affect planning objectives.

6.5.1 If native prairie restoration is not successful

Once the pilot study is completed, it may be determined that native prairie restoration is not feasible along transmission line rights-of-way. This may be the result of non-native species infiltration, herbicide drift, etc. If it is concluded that native restoration is not possible, then objectives should be refocussed on creating wildlife habitat. Even though it would be preferable to provide wildlife habitat while simultaneously restoring native vegetation, if either objective is met, then the environment,in general, is enhanced.

It would be a relatively simple procedure to allow grassland vegetation to grow along rights-of-way. The area could be left alone, and vegetation allowed to grow naturally, non-native vegetation species could be planted, or an arrangement could be made with the farmer to leave the right-of-way in crop (not swathed).

Priority should be given to those areas which landowners are most receptive. As both corridor network enhancement and patch connection may benefit wildlife species, either could be undertaken. If financial constraints exist, however, priority should be given towards patch connection areas identified, as these would probably benefit wildlife more in the short-term. Corridor network enhancement should be a continual process, with all possible transmission line rights-of-way identified included.

6.5.2 If native prairie restoration is successful

If it is determined, after the pilot study is completed, that native prairie restoration is a feasible management strategy for rights-of-way, planning should include both floral and faunal objectives.

While restoring native prairie on all of the identified rights-of-way should be a long-term objective, financial constraints may be cause for prioritization of certain areas. Mixed grass plantings should first occur where they may connect patches, which may be most beneficial to wildlife in the short-term, with all other areas subsequently being planted and managed. Tall grass areas nearest to the City of Winnipeg should be planted first. This may trigger increased interest from the public, and may be promoted (field trips for students, etc.).

In the event that native prairie restoration (or grassland revegetation) along the identified rights-of-way may run in conjunction with, or possibly complement, other habitat restoration projects, these areas could be given priority, and partnerships may be struck.

6.5.3 Adaptive right-of-way management

Regardless of the results of the pilot study, adaptive right-of-way management should be a primary consideration in any native prairie restoration or grassland revegetation project. If researchers are invited to participate at the outset of the project, experiments may be designed which will provide both scientists and rights-of-way managers with valuable information. Specific questions may be addressed, which are currently not answered in the literature. These experiments need not have a specific duration, but may continually provide information as new perturbations create new responses.

Chapter 7. Summary, Conclusions and Recommendations

7.1 Summary

A study area was selected between Brandon and Winnipeg, Manitoba. The study area was then methodically reduced in size to six study zones, which were of class 3, 4, 5, or 6 agricultural capability. All class 1, 2, and 7 lands were omitted. The study zones chosen were historically either tall or mixed grass prairie. Each study zone was individually investigated, first through physical observation, and then using aerial photographs. Transmission line corridors were identified and assessed as to their potential for connecting patches of non-native vegetation, and for the potential for native prairie restoration. Testing methods were devised which would provide sufficient information as to whether native prairie restoration is feasible, where it should be planted, and what maintenance technique would best suit it. Test sites were selected, and a restoration experiment was designed. The tests should run for a minimum of five years, and are designed to address botanical and zoological responses, although other tests could also be included. Different alternatives were suggested, in relation to a planning framework, depending on the results of the pilot study.

7.2 Conclusions

The purpose of this practicum has been to provide a planning framework which could be used in native prairie restoration projects along rights-of-way, applying concepts derived from general landscape ecology theory. The goal was to apply landscape theory, particularly patch connection and corridor network enhancement, to practical right-of-way management, ultimately to provide new avenues for biodiversity conservation. Although the study deals specifically with transmission line rights-of-way, the procedures could be applied to other linear facilities.

The study area was found to contain very little land which was not being farmed (cultivated). Study zones 1 and 2 contained almost no non-agricultural vegetation and while they offered good potential for native prairie restoration, they offered little for patch connection. Study zones 3 and 4 contained more patches of non-agricultural vegetation, and offered some opportunity for both prairie restoration and patch connection. Study zone 5 contained the greatest amount of non-agricultural vegetation and offered the greatest opportunity for prairie restoration and patch connection. Study zone 6 offered relatively poor opportunity for both prairie restoration or patch connection but in some areas did still contain large blocks of prairie (Township 10, Range 16, West of the 1st meridian). This creates the opportunity to preserve the existing native prairie which lies below the transmission line.

While the initial study primarily focused on testing the practical application of landscape theory, particularly patch connection, problems with this became apparent early into the investigation. It was soon realized that either an area contained too many patches, making empirical measurement extremely difficult (if possible at all), or the area was totally devoid of any patches near the rights-of-way. Additionally, patches which were near the line, particularly in study zone 5, were so large that testing would be too difficult and costly. It is concluded that rights-of-way within the study area provide little opportunity to test patch connection. There are areas identified, however, which should be considered first, if patch connection is desired. It should be noted that while the transmission line rights-of-way within the study area did not meet the criteria for adequate testing of patch theory, other rights-of-way, such as road-sides or railways may offer more opportunity.

Even after eliminating lands which are considered of highest quality, considerable areas remained in which native prairie restoration in cultivated lands might be feasible (725 ha). It was concluded that, prior to any large capital investment, a pilot study is needed. Recent literature indicates that there is no certainty whether native vegetation corridors (including prairie) are economically feasible, or of real benefit to native species. It is generally agreed that more information is needed, and that the "crucial experiments have not yet been performed" (Clark and Nudds, 1991). The pilot study will serve three purposes: it will contribute significantly to the existing information base; it will allow time to monitor other relevant research in the area of habitat restoration and incorporate it into the planning framework and; it will provide information necessary to the proponent to determine whether native prairie restoration is a feasible option in biological, technical, and economical terms.

It was recognized that forming partnerships for habitat management projects is a growing trend. Partnerships may not only add technical expertise to a project, but may also reduce costs of the project per partner, incorporate different viewpoints into the project, and generally make the project more comprehensive, in terms of size and scope.

A number of benefits may result from the restoration of native prairie along rights-of-way. Benefits of restoration can accrue to the rights-of-way manager, agriculturalists, wildlife, and to society in general.

Rights-of-way managers could benefit from prairie restoration primarily through reduced maintenance efforts and costs. Additionally, the need for herbicides in right-of-way management may be reduced.

Farmers with rights-of-way running through their lands may enjoy benefits similar to those resulting from shelterbelts. These include reduced wind erosion, soil stability, reduced damage to crops, and increased productivity in the long-term.

Native prairie could benefit various species of wildlife including birds, small mammals, and the larger mammals. Birds would be able to use the prairie grasses for nesting and as a food source. Small mammals would have cover

over the winter months, while large mammals would have an increased amount of forage. The rights-of-way could also serve as additional migration routes, allowing for increased movement of wildlife to new areas.

Society in general could benefit from native prairie restoration, as unique plant communities are preserved for future generations. The opportunity would exist for education and could encourage other projects to be undertaken.

It was also recognized that there are costs to native prairie restoration as well. Direct costs to project proponents include the purchase of native seed, sowing the seeds, and maintaining the site until the prairie could compete on its own. Additionally, compensation to landowners must also be considered.

Potential problems related to successful prairie restoration include the possibility of herbicide drift from adjoining fields, difficulties in regulating hunters who may see the rights-of-way as an attractive location to hunt, and the possibility of the new habitat attracting more birds, triggering increased bird strikes on power line wires. It was determined that the hunting problem could be mitigated through an agreement with the landowner, from whom hunters must ultimately get permission.

Finally, it was concluded that no matter what the results of the pilot study are, the study area offers researchers and rights-of-way managers an excellent opportunity to apply adaptive resource management theory to a large project. To "learn while doing" will not only create a long-term experimental infrastructure which may adapt to future development, but will provide the rights-of-way manager with an analysis tool in which they may truly understand the short and long-term effects of their decisions.

7.3 Recommendations

1. Following the specifications outlined in this study, a pilot study should be completed prior to any large-scale restoration efforts.

The pilot study outlined in this report will serve two important purposes: it will contribute much needed empirical data into the academic literature and; it will provide enough information to objectively assess the feasibility of native prairie restoration along rights-of-way.

2. Additional on-site research should be encouraged.

The pilot study is directed primarily at floral and faunal data collection and analysis. There is good potential for other research to be conducted at the test sites, creating an even greater database. Additional research may be undertaken in the disciplines of economics, social science, and natural or environmental science.

Economic research could include cost-benefit analyses, non-market valuations of native prairies, and economic implications of restoring native prairie along rights-of-way. Social research could include an analysis of the relative importance of prairie to the public, as opposed to other natural resources, or using native prairie restoration projects as an educational tool for the public. Environmental research could include soil erosion studies, wildlife transplanting onto rights-of-way, species migration patterns along corridors, as well as herbicide assessment.

3. Future rights-of-way planning should consider potential restoration criteria as well as existing native prairie.

When new projects which require rights-of-way are being undertaken, routes may be selected which satisfy the criteria outlined in this study for prairie restoration, thereby increasing potential restoration area. Additionally, routes may be selected so the rights-of-way preserve and protect existing prairie, without the need for restoration.

4. Further research on patch connection is necessary.

While power line rights-of-way *within the study area* provided little opportunity for testing patch connection, other rights-of-way should be investigated. These would include active and abandoned road and railway rights-of-way, stream corridors, and transmission lines outside of the study area.

Literature Cited

Accutrak Systems Ltd. (1991). A Study to Determine the Cost of Farming Around an Obstacle. Prepared for the North America Wildlife Foundation, December, 1991.

Anderson, S.H., Mann, K., & Shugart, H.H. (Jr.) (1977). The Effect of Transmission Line Corridors on Bird Populations. American Midland Naturalist, 97, 216-221.

Armstrong, P.K. (1990). Three No-Till Methods of Establishing Prairie on Small Sites, (Abstract Only). Twelfth North American Prairie Conference, Program and Abstracts. Cedar Falls, Iowa: pg 26.

Belcher, K. (1991). An Evaluation of the Economic Impact of Wildlife Habitat Enhancement Options on Individual Landowners in Western Manitoba. Practicum, Natural Resources Institute, University of Manitoba.

Betz, R.F. (1986). One Decade of Research in Prairie Restoration at the Fermi National Accelerator Laboratory (Fermilab). In The Prairie: Past, Present and Future -proceedings from the Ninth North American Prairie Conference. G.K. Clambey and R.H. Pemble eds. Tri-College University Center for Environmental Studies. North Dakota State University. Fargo, North Dakota: 179-184.

Berg, W.A. (1990). Native Forb Performances in Grass-forb Seedings (Abstract Only). Twelfth North American Prairie Conference, Program and Abstracts. Cedar Falls, Iowa; pg. 25

Bird, R.D. (1961). Ecology of the Aspen Parkland of Western Canada, Canada Department of Agriculture, Ottawa.

Bossenmaier, E.F. & Vogel, C.G. (1974). Wildlife and Wildlife Habitat within the Winnipeg Region. Winnipeg: Manitoba Department of Mines, Resources and Environmental Management.

Bowen, R. (1990). Prairie Restorations Inc.: A Statement of Products and Services, Princeton, Minnesota.

Cain, S.A. (1968). General Ecology, Human Ecology and Conservation. Department of Conservation Resource Planning and Conservation, East Lansing: University of Michigan.

Chasko, G.G., & Gates, J.E. (1982). Avian Habitat Suitability Along a Transmission Line Corridor in Oak-Hickory Forest Region. Wildlife Monographs, 82, 1-41.

Clark, R.G. and T.D. Nudds (1991). Habitat Patch Size and Duck Nesting Success: The Crucial Experiments Have Not Been Performed. Wildlife Society Bulletin, 19, 534-543.

Clark, R.G. and T.D. Nudds (1992). Landscape Ecology, Adaptive Resource Management and The North American Waterfowl Management Plan.

Collicutt, D.R. & Morgan, J.P. (1991). Tall Grass Prairie Restoration Project: 1990 Report. Prairie Habitats, Argyle, Manitoba.

Croze, H. & Vanderweerd, V. (1991). Monitoring and Data Management Technology for Environmental Assessment. Proceedings from the Environmental Information Forum. Montreal.

Desjardins, R. (1983). Impact of Obstacles on Farm Operations. A Report to the Department of Municipal Affairs, Government of Alberta, Technical Report 83-08-10.

Doupe, J. (1873). Government of Manitoba Field Survey Notebook. Courtesy Manitoba Public Archives. No. 375

Durant, J. (No Date). Using Native Species in Roadside Vegetation Management: An Economic, Technical, and Environmental Assessment of the Feasibility for Application in Manitoba. Unpublished practicum, Natural Resources Institute, University of Manitoba.

Forman, R.T.T. (1987). Emerging Directions in a Landscape Ecology and Applications in Natural Resource Management. In R. Hermann & T. Bostedt-Craig (Eds)., Conference Proceedings, Science in the National Parks, Vol. 1. Fort Collins, Co.: U.S. National Park Service and George Wright Society.

Forman, R.T.T. (1982). Interactions Among Landscape Elements in Perspectives in Landscape Ecology. Proceedings from the International Congress of the Netherlands Society for Landscape Ecology, Veldhoven, 1981., Pudoc, Wageningen, The Netherlands.

Forman, R.T.T., & Godron, M. (1981). Patches and Structural Components for a Landscape Ecology. Bioscience, 31: 733-740.

Forman, R.T.T. (1979). The Pine Barrens of New Jersey: An Ecological Mosaic. In R.T.T. Forman (Ed.), Pine Barrens: Ecosystem and Landscape. New York: Academic Press.

Galli, A.E., Leck, C.F., & Forman, R.T.T. (1976). Avian Distribution Patterns Within Different Sized Forest Islands in Central New Jersey. Auk, 93, 356-364.

Gates, J.E. (1991). Corridors. In Wildlife Habitats in Managed Landscapes, J.E. Rodiek and E.G. Bolen eds. Island Press Publishing, Washinton.

Gates, J.E. and Gysel, L.W. (1978). Avian Rest Dispersion and Fledgling Success in Field-Forest Ecotones. Ecology, 59, 871-883.

Gottfried, B.M. (1979). Small Mammal Populations in Woodlot Islands. American Midland Naturalist, 102, 105-112.

Government of Canada

(1966). Canada Land Inventory (Manitoba). Minister of Supply and Services, Ottawa.

(1991). The State of Canada's Environment. Minister of Supply and Services, Ottawa.

(1992). A Landownwers Guide. Conservation of Canadian Prairie Grasslands. Minister of Supply and Services, Ottawa.

Government of Manitoba

(1983). In Thomas R. Weir (Ed.), Atlas of Manitoba. Department of Natural Resources.

(1991). State of the Environment Report. Minister of Environment, Manitoba.

Harris, L.D. (1988). Landscape Linkages: A dispersal corridor approach to wildlife conservation. Transcripts, North American Wildlife and Natural Resources Conference, 54, 595-607.

Hobbs, R, J. (1992) Trends in Ecology and Evolution, Volume 7, no. 11, 389.

Hole, F.D. and G.A. Nielson (1970). Soil Genesis Under Prairie. Prairie and Prairie Restoration. University of Kansas Press: 28-34

Holling, C.S. (1978). Adaptive Environmental Assessment and Management. International Institute for Applied Systems Analysis.

Holling, C.S. and W.C. Clark (1975). Notes Towards a Science of Ecological Management. In: Unifying Concepts in Ecology. W.H. Van Dobben and R.H. Lowe-McConnell eds. W. Junk, The Hague:247-251

Hulbert, L.C. (1986). Fire Effects on Tall Grass Prairie. In The Prairie: Past, Present and Future - proceedings from the Ninth North American Prairie Conference. G.K. Clambey and R.H. Pemble eds. Tri-College University Center for Environmental Studies. North Dakota State University. Fargo, North Dakota: 138-142.

Jacobson, E.T., Tober, D.A., Haas, R.J., and D.C. Darris (1986). The Performance of Selected Cultivars of Warm Season Grasses in the Northern Prairie and Plains States. In The Prairie: Past, Present and Future - proceedings from the Ninth North American Prairie Conference. G.K. Clambey and R.H. Pemble eds. Tri-College University Center for Environmental Studies. North Dakota State University. Fargo, North Dakota: 215-222.

Jahn, L.R. (1991). Forward in Wildlife Habitats in Managed Landscapes. J.E. Rodiek and E.G. Bolen eds. Island Press Publishing, Washington.

Johnson, W.C., Schreiber, R.K. and Burgess, R.L. (1979). Diversity of Small Mammals in a Powerline Right-of-Way and Adjacent Forest in East Tennessee. American Midland Naturalist, 101, 231-235.

Josephson, R.M. (1992). An Economic Evaluation of Land Use Changes in Southwest Manitoba. A report to the Manitoba Habitat Heritage Corporation. November, 1992.

Joyce, J. (1990). Prairie Grasslands Guidebook - A Management Manual. Critical Wildlife Habitat Program, Manitoba Department of Natural Resources. Winnipeg

Le Ber, H. (1873). Government of Manitoba Field Survey Notebook. Courtesy Manitoba Public Archives. No. 259.

Leskiw, C.M. (1978). Guidelines for the Preservation, Propagation, and Utilization of Native Grass Prairies in Manitoba. Natural Resources Institute Practicum. Winnipeg: University of Manitoba.

Lines, L.G. & Harris, L.D. (1989). Isolation of Nature Reserves in North Florida Measuring Linkage Exposure. Transcripts, North American Wildlife and Natural Resources Conference, 54, 113-120

Mader, H.J. (1984). Animal Habitat Isolation By Roads and Agricultural Fields. Biological Conservation 29:81-96

Manitoba Hydro (1992). How Does a Transmission Line Affect Wildlife and Habitat? A discussion paper included in the Split Lake Transmission Line Project - Site Selection and Environmental Assessment. Environment Act Proposal (April, 1992)

Maurer, B. A. (1986). Predicting Habitat Quality for Grassland Birds Using Density-Habitat Correlations. Journal of Wildlife Management. Vol. 50(4): 556-566

McClain, W.E. (1986). Illinois Prairie: Past and Future - A restoration Guide. Illinois Department of Conservation.

Moore, N.W. & Hooper, M.D. (1975). On The Number of Bird Species in British woods. Biological Conservation., No. 8, 239-250.

Morgan, K.A. & Gates, J.E. (1983). Use of Forest Edge and Strip Vegetation by Eastern Cottontails. Journal of Wildlife Management, No. 47, 259-264.

Nudds, T. (1992). Adaptive Resource Management Means Never Having To Say You're Sorry. March, 1992.

O'Grady, L. (1990). Integrated Resource Management Planning on the Pembina Escarpment: The Deerwood Experience. Practicum. Natural Resources Institute, University of Manitoba.

Pickett, S.T.A. & White, P.S. (1985). The Ecology of Natural Disturbance and Patch Dynamics. Academic Press.

Reid, J.L. (1872). Government of Manitoba Field Survey Notebook. Courtesy Manitoba Public Archives. No. 58

Richard, J.B. (1872). Government of Manitoba Field Survey Notebook. Courtesy Manitoba Public Archives. No. 141.

Rock, H.W. (1981). Prairie Propagation Handbook. Wehr Nature Center, Milwaukee County Department of Parks, Recreation and Culture. Franklin, Wisconsin.

Rodiek, J.E. (1991). Wildlife Habitats in Managed Landscapes. J.E. Rodiek and E.G. Bolen eds. Island Press Publishing, Washington.

Saunders, D.A., Hobbs, R., and C.R. Margules (1990). Biological Consequences of Ecosystem Fragmentation: A Review. Conservation Biology. Vol. 5, No. 1: 18-32

Simberloff, D. and J. Cox (1987). Consequences and Costs of Conservation Corridors. Conservation Biology. Vol. 1, No. 1, 63-71

Simberloff, D., Farr, J. A., Cox, J., and D.W. Mehlman (1992). Movement Corridors: Conservation Bargains or Poor Investments. Conservation Biology. Vol. 6, No. 4: 493-504.

Sinclair, A.R.E. (1992). Science and the Practice of Wildlife Management. Presented at the 57th North American Wildlife and Natural Resources Conference, Charlotte, North Carolina, March, 1992.

Soule, M.E. (1986). Conservation Biology: The Science of Scarcity and Diversity. Sinauer Associates, Sunderland, Ms.

Sutton, V. (1983). An Evaluation Of Landowners Attitudes Toward Field Shelterbelts in Agro-Manitoba: A Case Study of the Lyleton Area. Practicum. Natural Resources Institute, University of Manitoba.

Walters, C.J. (1986). Adaptive Management of Renewable Resources. Mac Millan Publishing Company, New York.

Walters, C.J. and R. Hilborn (1976). Adaptive Control of Fishing Systems. Journal of Fish Resources Board Canada. 33: 145-159

Walters, C.J. and J.S. Collie (1988). Is Research on Environmental Effects on Recruitment Worthwhile? Canadian Journal of Fisheries and Aquatic Sciences. 45: 1848-1854

Walters, C.J. and C.S. Holling (1990). Large -Scale Management Experiments and Learning by Doing. Ecology. 71(6):2060-2068

Watts, R. (1969). Vegetation, Soils and Wildlife. In J.G. Nelson & M.J. Champers (Eds.), Vegetation, Soils and Wildlife.

Weaver, J.E. (1954). North American Prairie. Lincoln, Nebraska: Johnson Publishing Company.

Webb, A.C.

(1872). Government of Manitoba Field Survey Notebook. Courtesy Manitoba Public Archives. No 188.

(1873). No. 353.

Wilcore, D.S. (1985). Nest Predation in Forest Tracts and the Decline of Migratory Songbirds. Ecology, 66, 1211-1214.

Wilson, J. (1970). How to Get a Stand of Native Grass in Nebraska. In Proceedings of a Symposium on Prairie and Prairie Restoration. P. Schramm, ed. Knox College Special Publication No. 3. Galesburg, Illinois.

Wilson, S.D. and J.W. Belcher (1989). Plant and Bird Communities of Native Prairie and Introduced Eurasian Vegetation in Manitoba Canada. Conservation Biology. Volume 3, No. 1: 39-44

Woehler, E.E. (1981). A Review of Herbicide Use in Establishing Native Prairie Grasses (Abstract Only). In The Prairie Peninsula - In the Shadow of Transeau: Proceedings of the Sixth North American Prairie Conference. R.L. Stuckey and K.J. Reese, eds. College of Biological Sciences, Ohio State University, Columbus,Ohio: pg. 263

Personal Communications

Armstrong, L. December, 1992. Statistical Consultant, Statistical Advisory Committee, University of Manitoba.

Dubois, J. January, 1993. Director, Living Prairie Museum, Winnipeg, Manitoba.

Kenkel, N. December, 1992. Department of Botany, University of Manitoba.

Mann, R. - June, 1992. Vegetation Management Specialist, Manitoba Hydro.
- February, 1993.

Morgan, J. December 1992. Manager, Prairie Habitats, Argyle , Manitoba.

Morrison, I. February, 1993. Department of Plant Science, University of Manitoba.

Appendices

Appendix 1 - Newspaper article

Let tall grass stand, petitions tell city hall

Transcona

By Nick Martin
Metro Reporter

The message is pretty clear, says Coun. Rick Boychuk (Transcona) — keep your mitts off the Bradley tall grass prairie.

Boychuk says there is overwhelming support, among hundreds of residents who have responded to questionnaires and petitions, for the argument that any new Transcona beltway not touch the rare tall grass prairie site along Bradley Street.

Boychuk intends to table those petitions at Tuesday's meeting of works and operations committee, which will consider an East Kildonan-Transcona community committee recommendation that the Bradley site be preserved in its entirety.

Boychuk said most residents believe that if any new roads are needed in Transcona, there shouldn't be any north-south development. "We have Lagimodiere. We don't need to waste tax dollars to have another north-south roadway."

However, many residents would consider an east-west project, such as extending Devonshire Drive to Concordia Avenue, or Ravelstone Avenue West to Lagimodiere Boulevard.

Don't need roadway

Dave and Jean Popovich of Stony Lake Bay told Boychuk another major roadway would devastate a quiet and peaceful neighborhood.

"We find it very disturbing that our tax dollars would be used to destroy a rare prairie grass area in order to build a roadway, that most residents (we've) spoken to don't want and feel we don't need," the Popovich family wrote to Boychuk.

"As far as another major highway is concerned, it is needed about as much as the x-rated video stores are needed — which is not at all," wrote T.W. and Faye Serofin of Kildare Avenue.

Winnipeg Free Press
Saturday, September 5, 1992

Appendix 2 - Description of Soil Classifications (From Canada Land Inventory, 1966)

Class 2. Soils in this class have moderate limitations that restrict the range of crops or require moderate conservation practices.

The soils are deep and hold moisture well. The limitations are moderate and the soils can be managed and cropped with little difficulty. Under good management they are moderately high to high in productivity for a wide range of crops.

Class 3. Soils in this class have moderately severe limitations that restrict the range of crops or require special conservation practices.

The limitations are more severe than class 2 soils. They affect one or more of the following practices: timing and ease of tillage; planting and harvesting; choice of crops; and methods of conservation. Under good management they are fair to moderately high in productivity for a fair range of crops.

Class 4. Soils in this class have severe limitations that restrict the range of crops or require special conservation practices, or both.

The limitations seriously affect on or more of the following practices: timing and ease of tillage; planting and harvesting; choice of crops; and methods of conservation. The soils are low to fair in productivity for a fair range of crops but may have high productivity for a specially adapted crop.

Class 5. Soils in this class have very severe limitations that restrict their capability to producing perennial forage crops, and improvement practices are feasible.

The limitations are so severe that the soils are not capable of use for sustained production of annual field crops. The soils are capable of producing native or tame species of perennial forage plants, and may be improved by use of farm machinery. The improvement practices may include clearing of bush, cultivation, seeding, fertilizing, or water control.

Class 6. Soils in this class are capable only of producing perennial forage crops, and improvement practices are not feasible.

The soils provide some sustained grazing for farm animals, but the limitations are so severe that improvement by use of farm machinery is impractical. The terrain may be unsuitable for use of farm machinery, or the soils may not respond to improvement, or the grazing season may be very short.

Appendix 3 - Preliminary Cost Schedule (Three years) for Initial Planting and Maintenance of Six Test Plots in Four Study Zones

<u>Year 1</u>

Planting ($2,000/acre x 12 acres) $24,000.00

<u>Year 2</u>

Maintenance ($45.00/hr mowing x 36 hrs. x 3 times per year 4.860.00

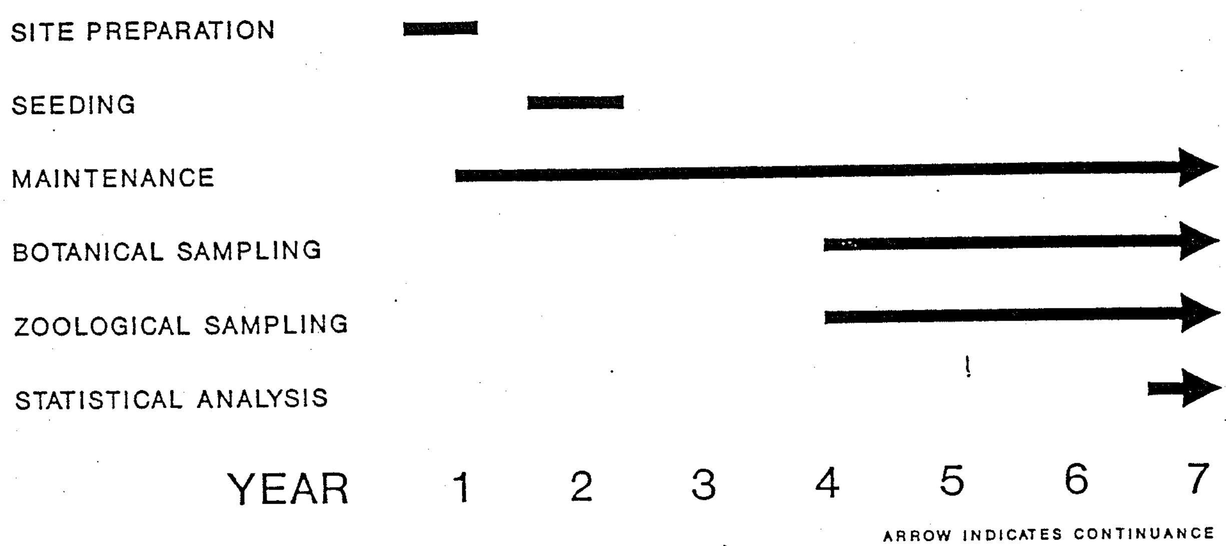
<u>Year 3</u>

Maintenance 4,860.00

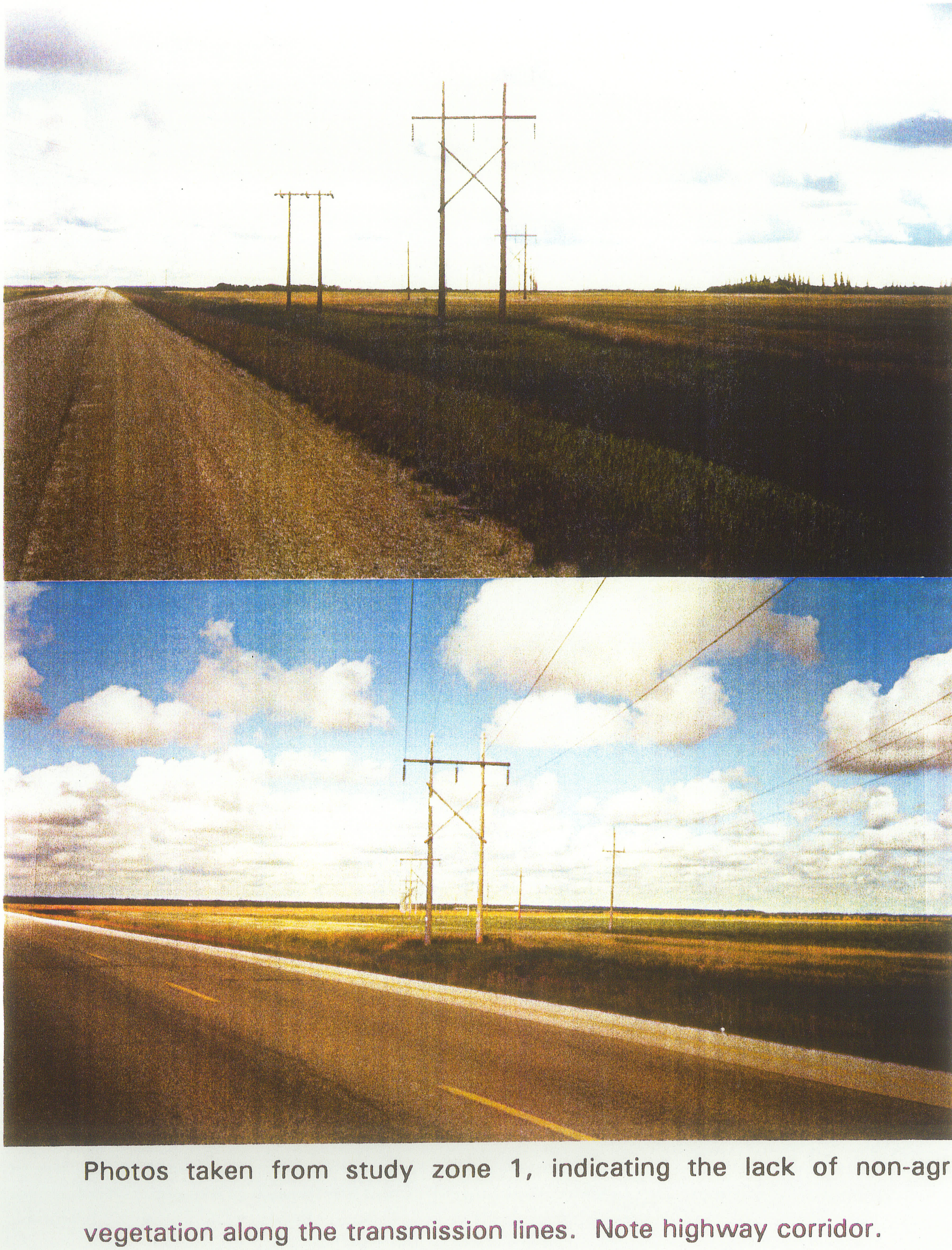
Total **$33,720.00**

(costs quoted by Prairie Habitats, 1992)

Appendix 4 - Project Time Line

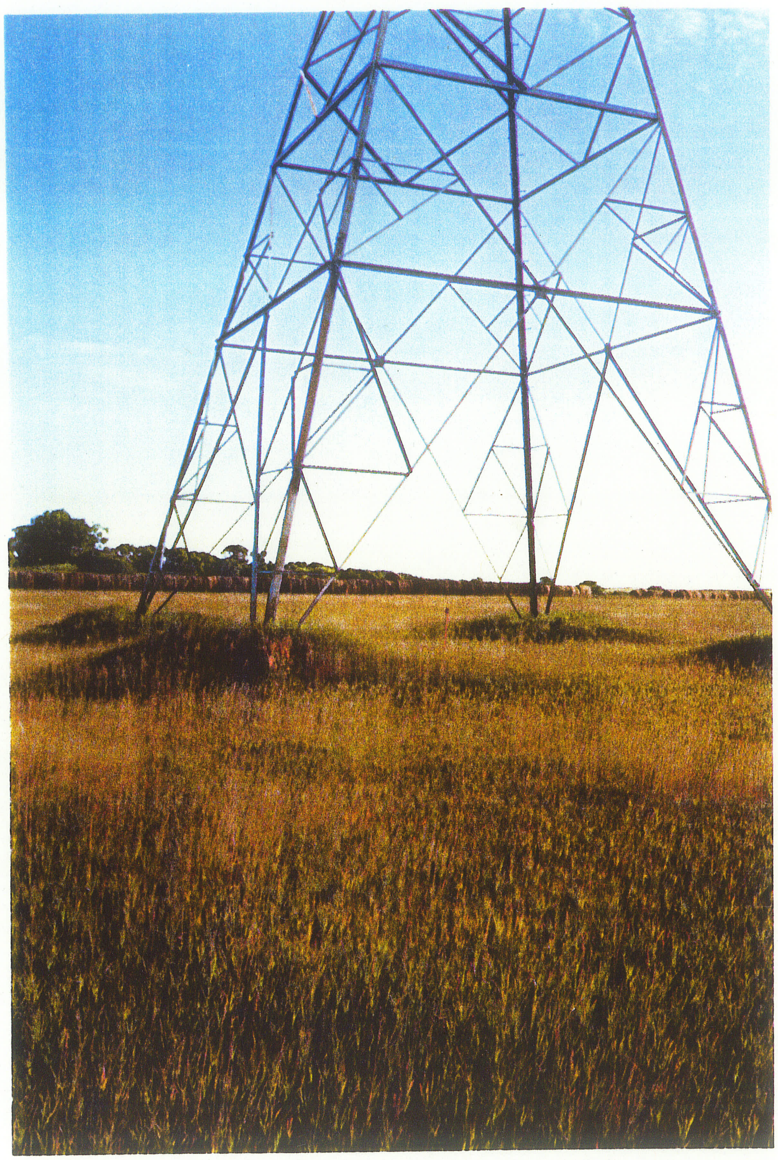


Appendix 5 - Field photographs



Photos taken from study zone 1, indicating the lack of non-agricultural vegetation along the transmission lines. Note highway corridor.

Photos taken from study zone 2. Note marginal crops.



Grasslands will do little to hinder the general maintenance of transmission lines (Study zone 6).

In some cases, transmission lines are already providing habitat corridors (Study zone 5).

Appendix 6 - Potential Partnerships

*Note. These agencies have **not** been contacted. They are only some possible agencies which **may** be interested in prairie restoration.

Manitoba Department of Highways and Transportation
Manitoba Parks
Manitoba Sustainable Development Unit
Manitoba Wildlife
Manitoba Agriculture
Agriculture Canada
Environment Canada
City of Winnipeg Parks and Recreation
City of Winnipeg Living Prairie Museum
Canadian Wildlife Service
Manitoba Naturalists Society
Ducks Unlimited
North American Waterfowl Management Plan
University of Manitoba
- Agriculture
- Landscape Architecture
- Zoology
- Botany

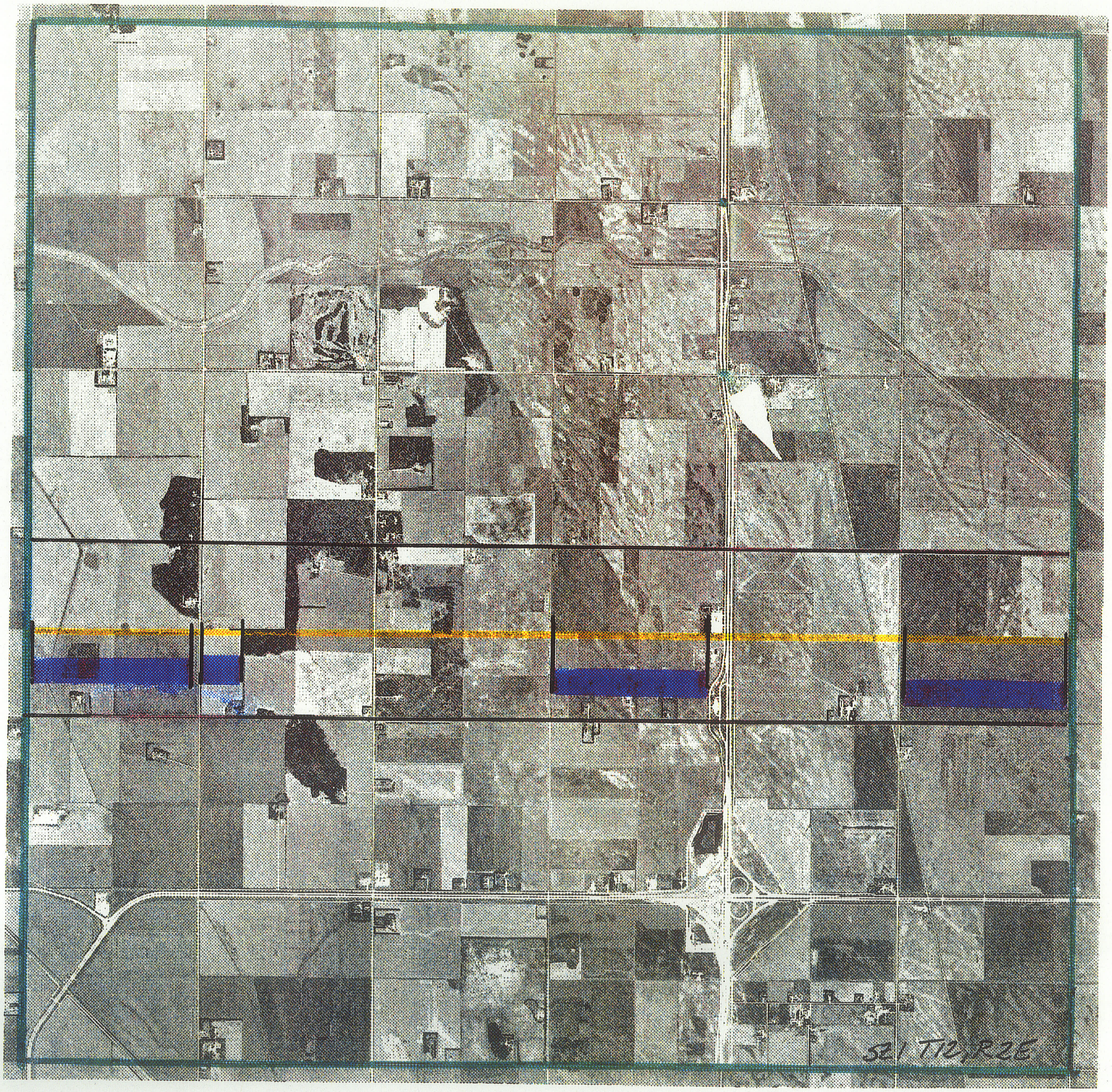
University of Winnipeg
Wildlife Habitat Canada
Prairie Habitats

Appendix 7 - Transmission line survey

Study zone 1

Township 12
Range 2
East of 1st meridian

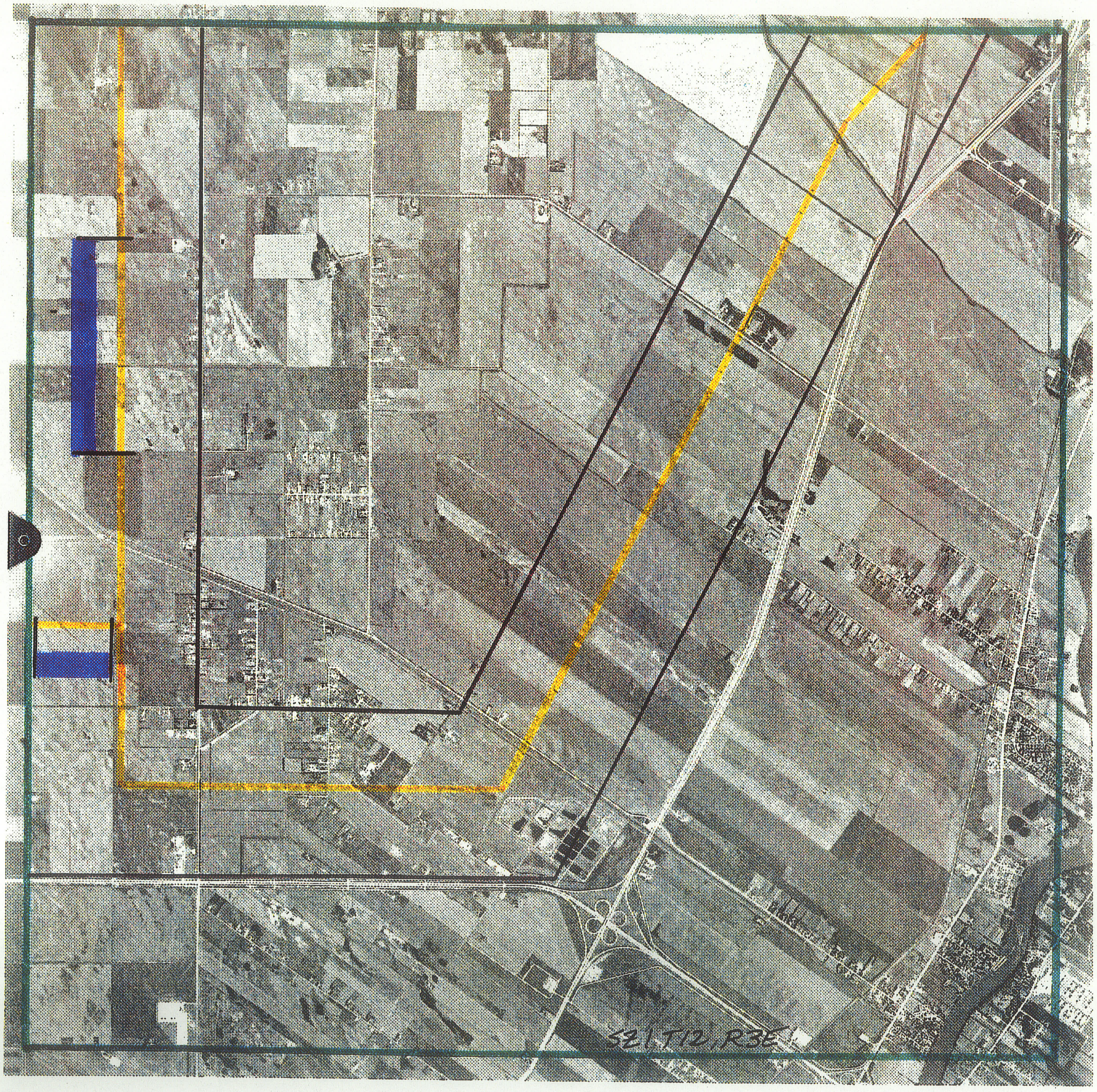
Prairie restoration (blue) = 39 acres (15.8 ha)



Study zone 1

Township 12
Range 3
East of 1st meridian

Prairie restoration (blue) = 25 acres (10 ha)



Study zone 1

Township 13
Range 1
East of 1st meridian

Prairie restoration (blue) = 37 acres (15 ha)
Patch connection (red) = 18.5 acres (7.5 ha)

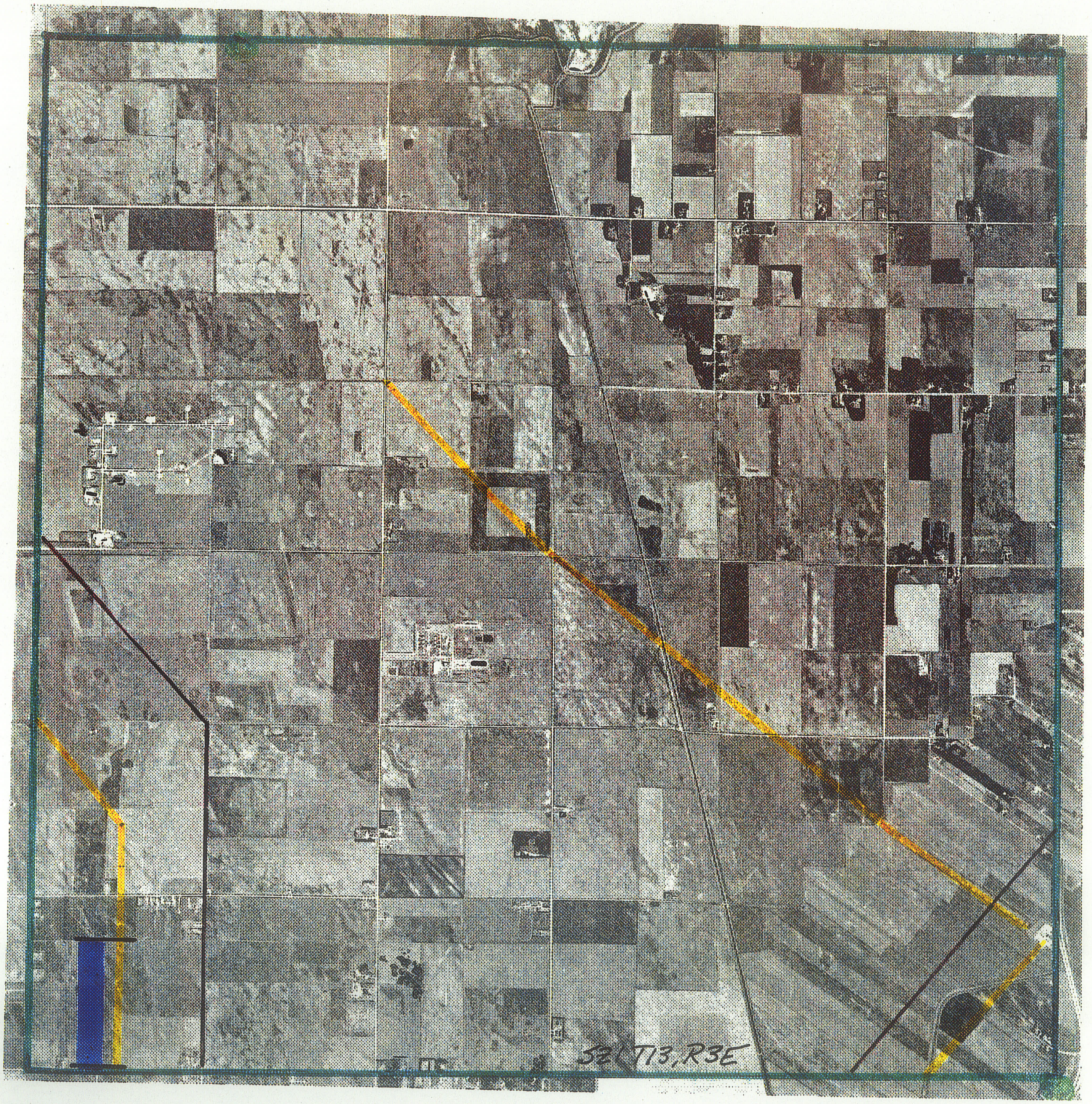
Study zone 1

Township 13
Range 2
East of 1st meridian

Study zone 1

Township 13
Range 3
East of 1st meridian

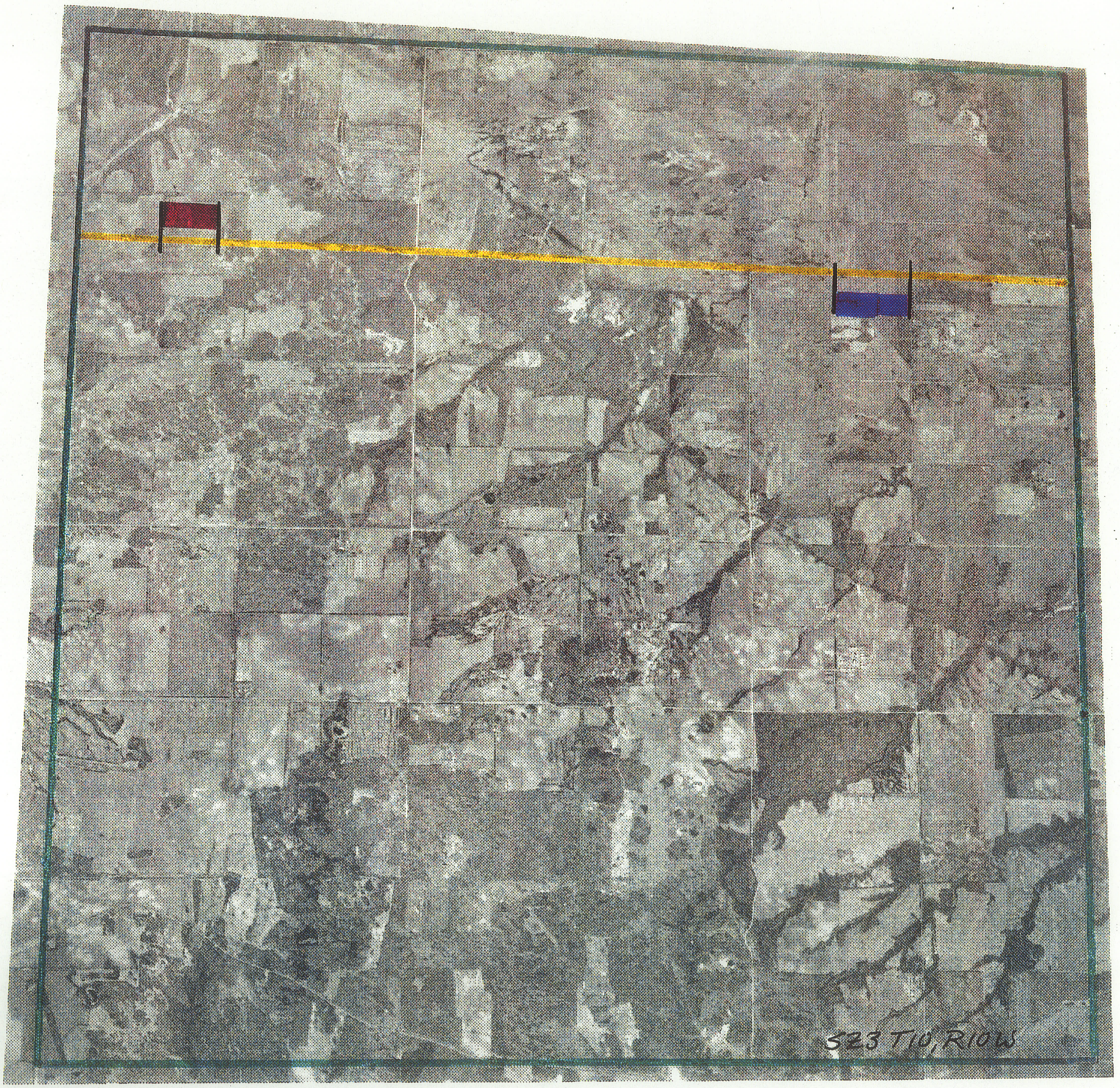
Prairie restoration (blue) = 9 acres (3.6 ha)



Study zone 3

Township 10
Range 10
West of 1st meridian

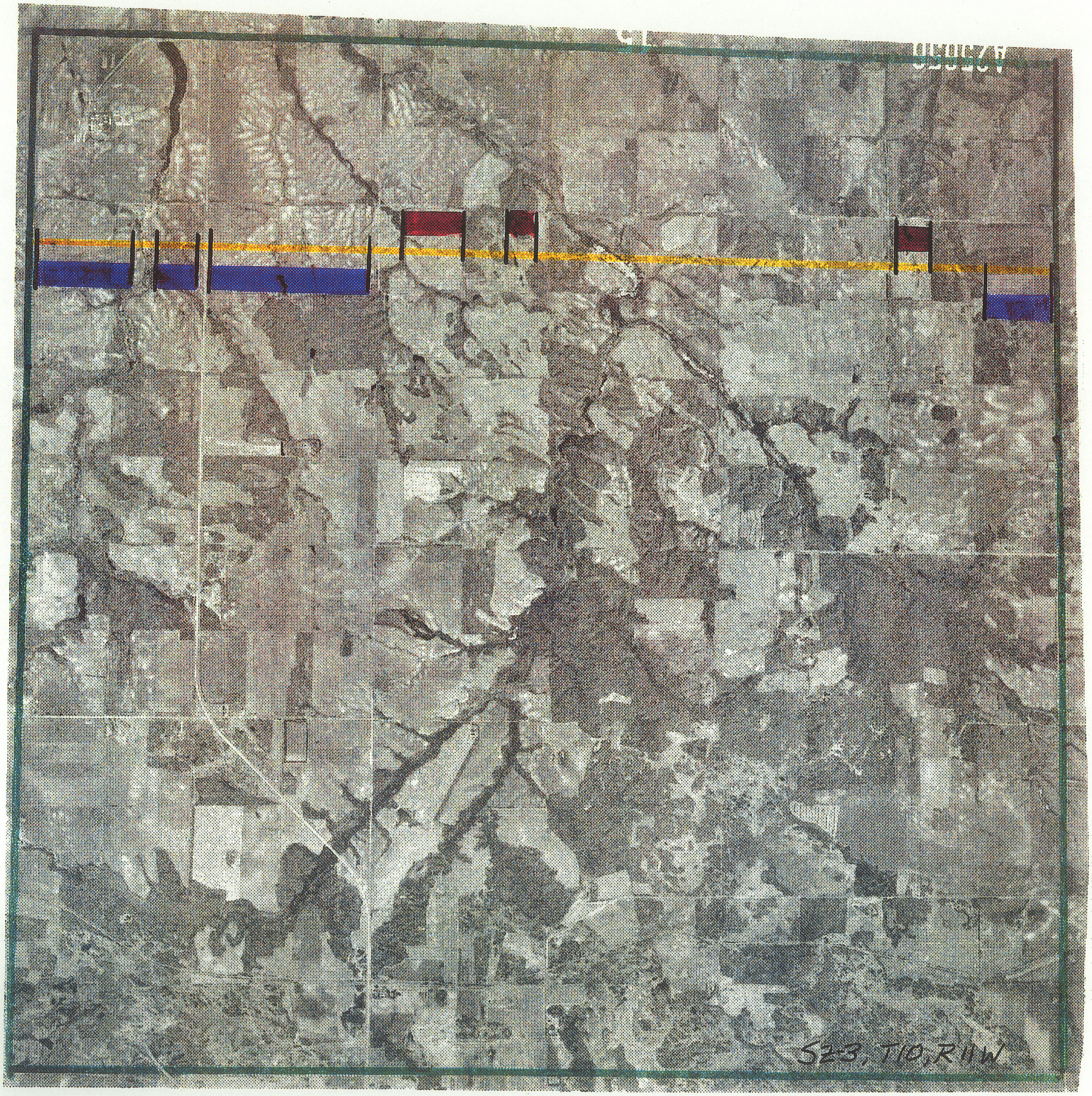
Prairie restoration (blue) = 6 acres (2.4 ha)
Patch connection (red) = 5 acres (2 ha)



Study zone 3

Township 10
Range 11
West of 1st meridian

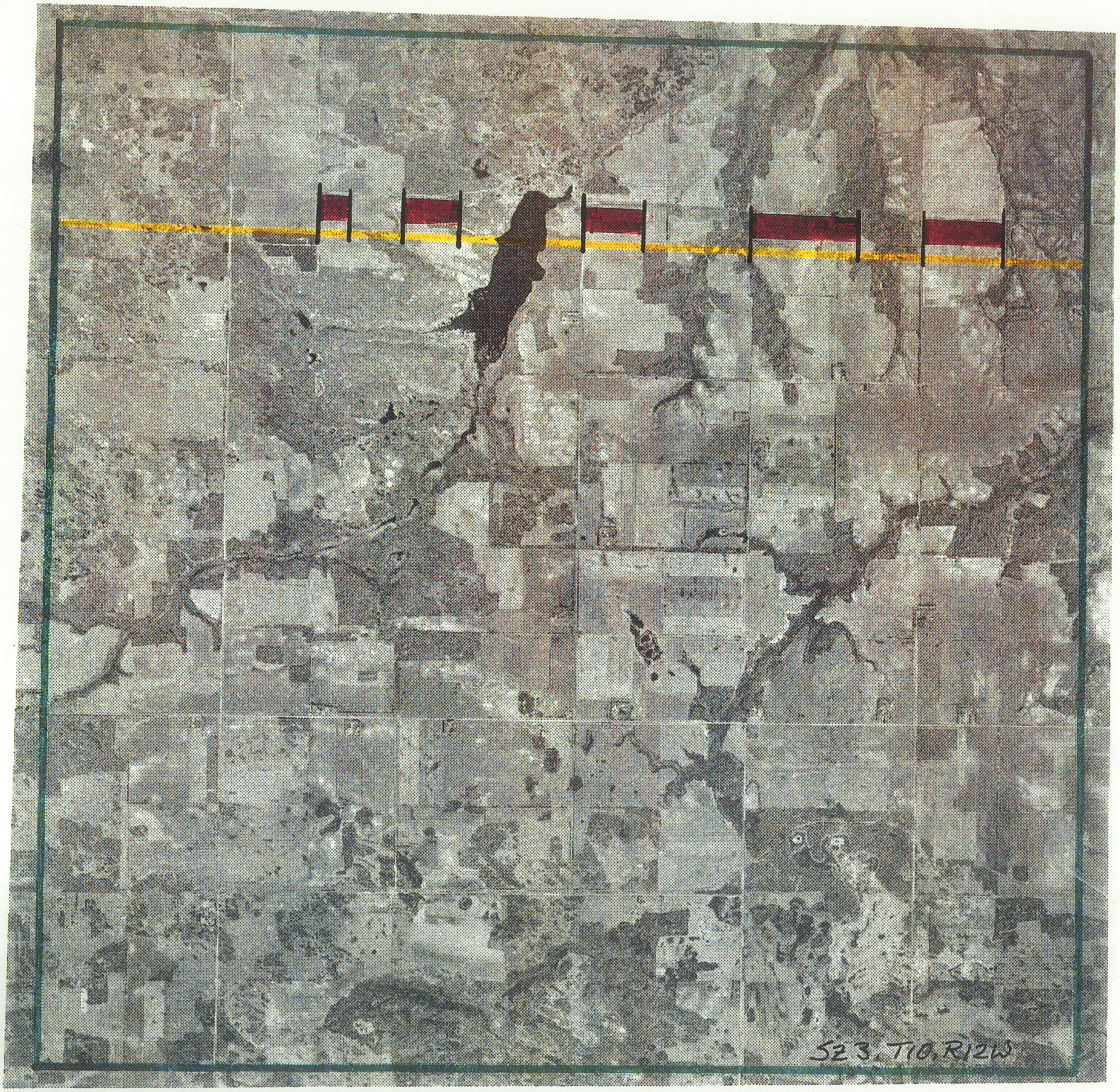
Prairie restoration (blue) = 27 acres (10.9 ha)
Patch connection (red) = 10 acres (4 ha)



Study zone 3

Township 10
Range 12
West of 1st meridian

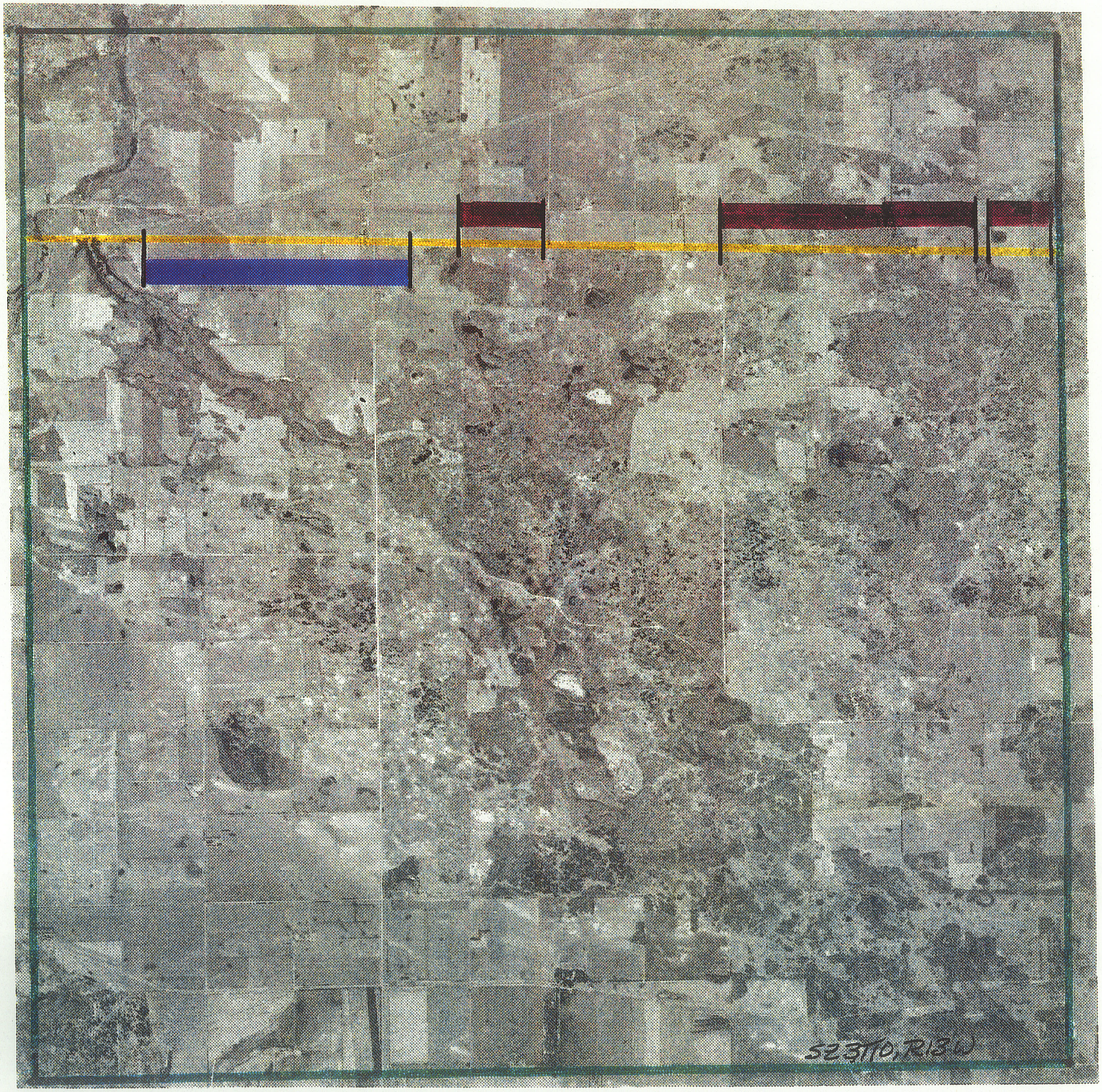
Patch connection (red) = 27 acres (10.9 ha)



Study zone 3

Township 10
Range 13
West of 1st meridian

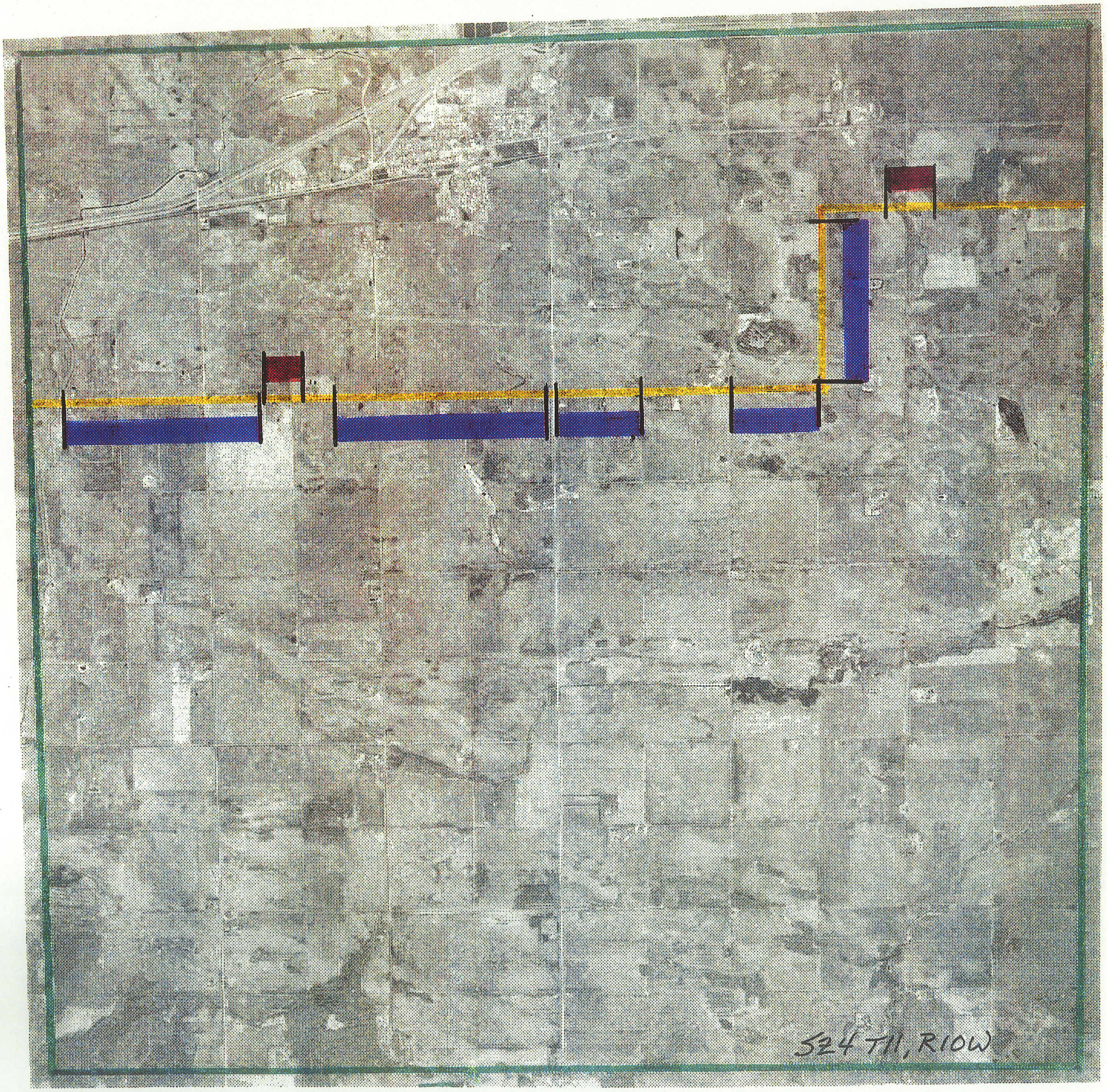
Prairie restoration (blue) = 18 acres (7.2 ha)
Patch connection (red) = 31 acres (12.5 ha)



Study zone 4

Township 11
Range 10
West of 1st meridian

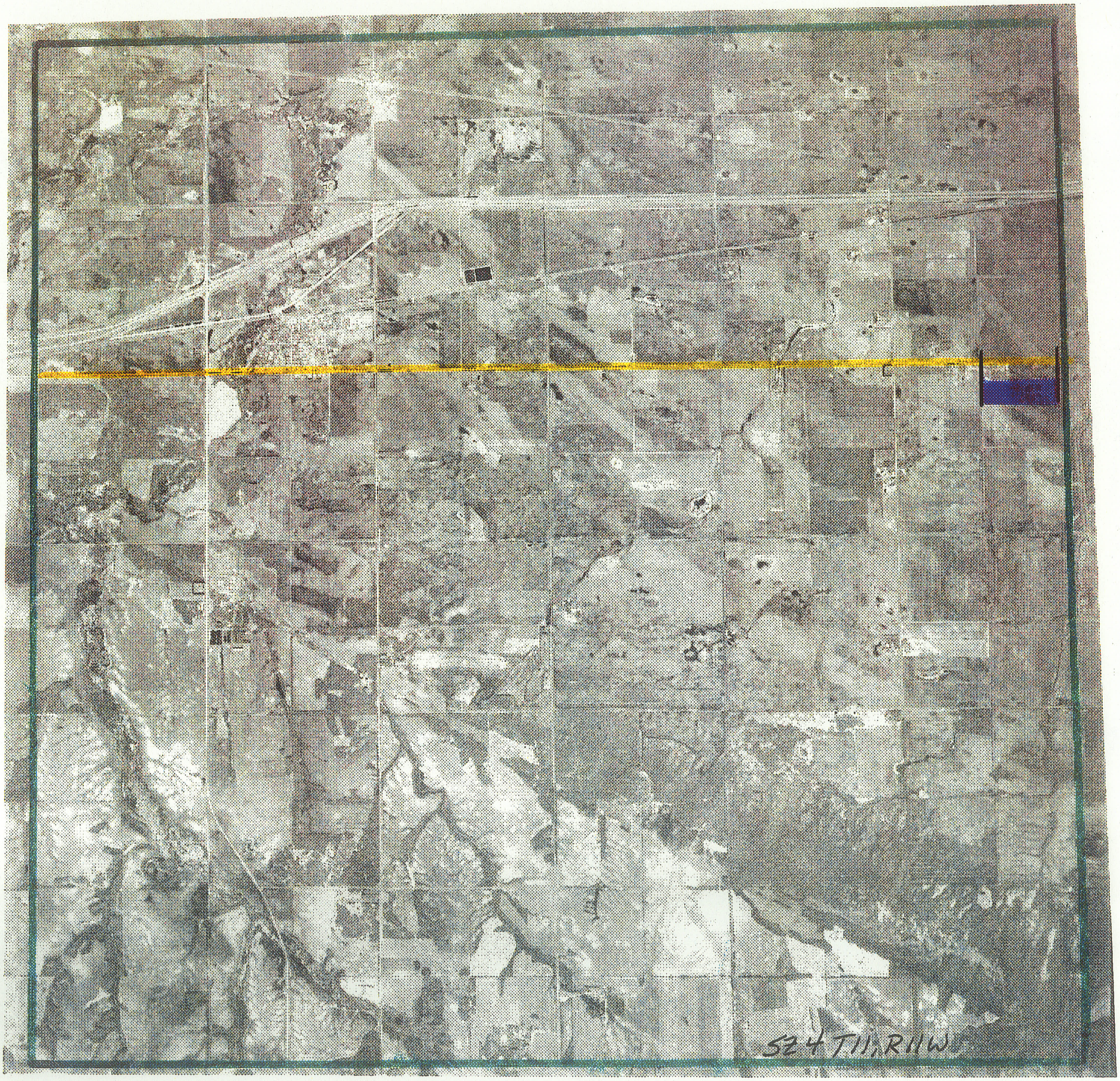
Prairie restoration (blue) = 50 acres (20.2 ha)
Patch connection (red) = 7 acres (2.8 ha)



Study zone 4

Township 11
Range 11
West of 1st meridian

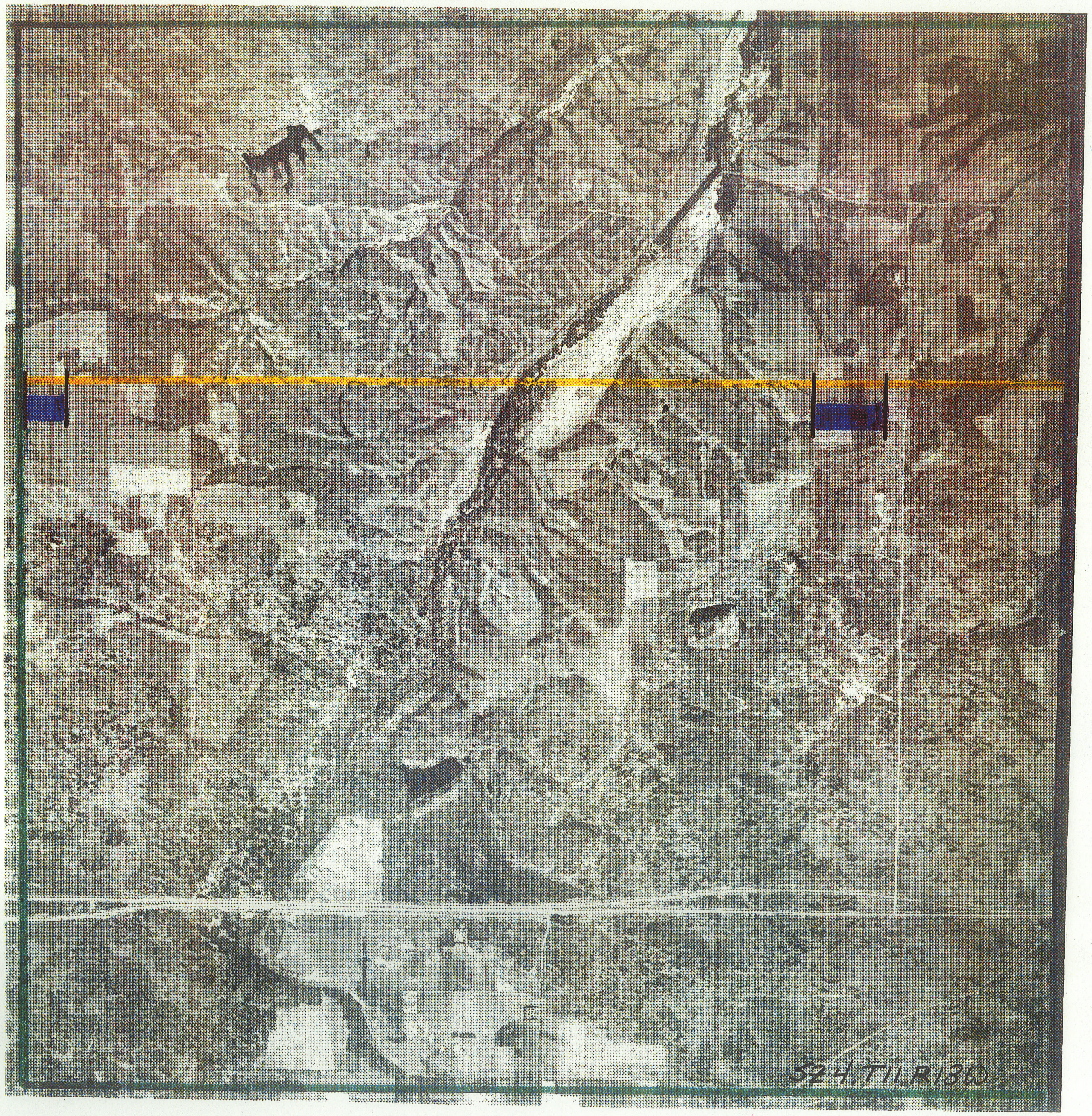
Prairie restoration (blue) = 6 acres (2.4 ha)



Study zone 4

Township 11
Range 13
West of 1st meridian

Prairie restoration (blue) = 8 acres (3.2 ha)

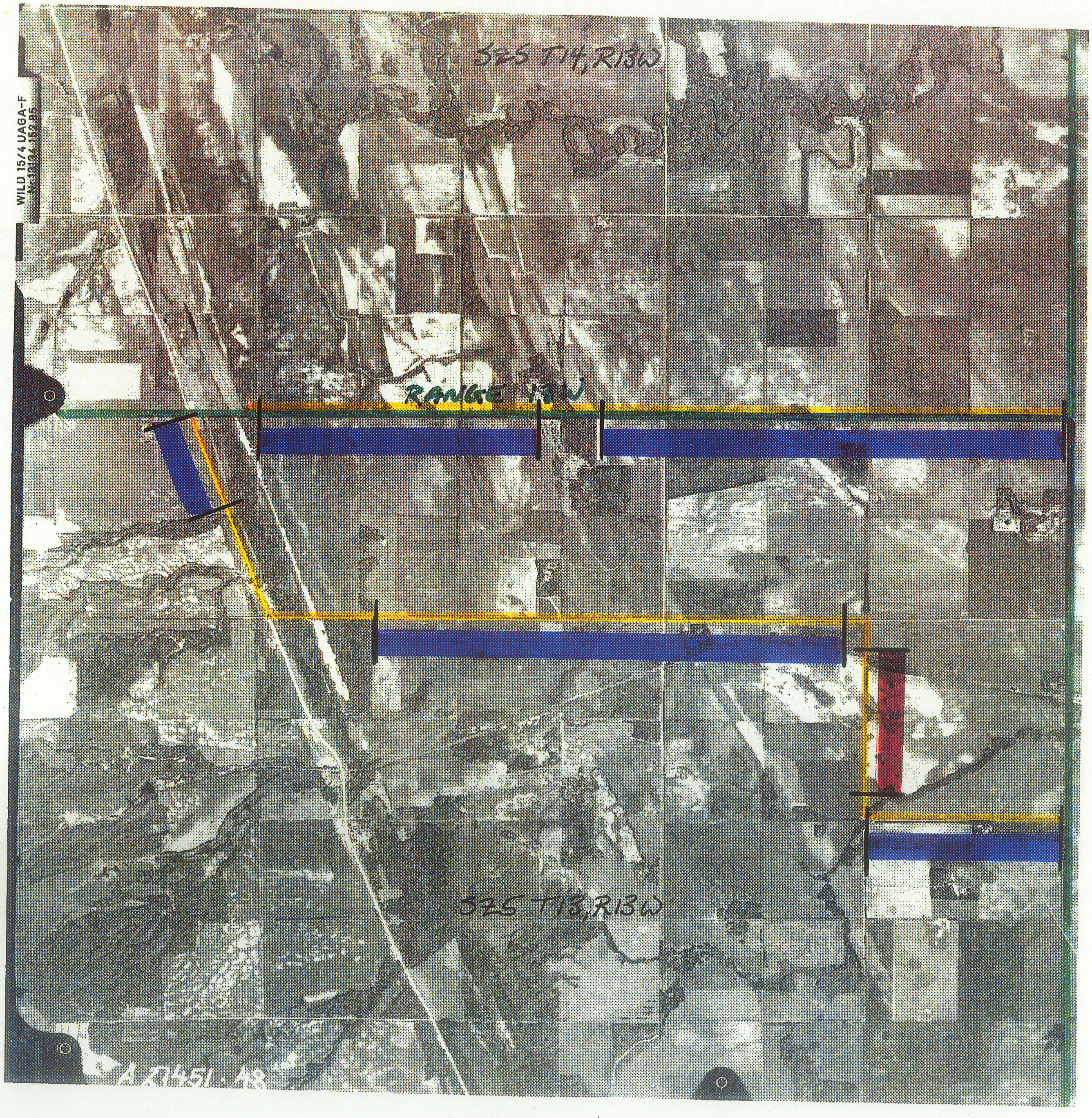


Study zone 5

<u>Bottom</u>
Township 13
Range 13
West of 1st meridian

<u>Top</u>
Township 14
Range 13
West of 1st meridian

Prairie restoration (blue) = 94 acres (38 ha)
Patch connection (red) = 8 acres (3.2 ha)



Study zone 5 (west)

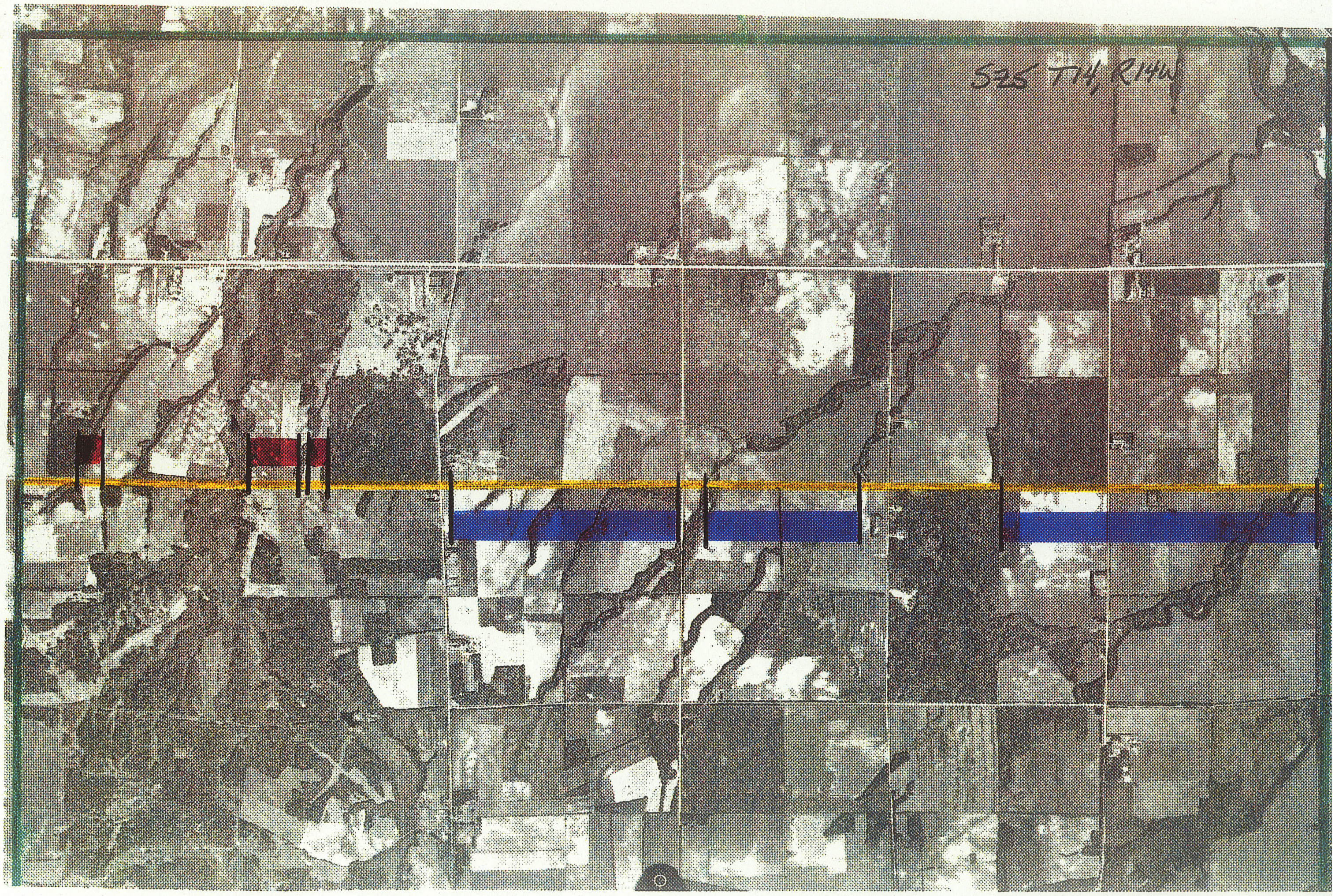
Township 14
Range 13
West of 1st meridian

Prairie restoration (blue) = 49 acres (19.8 ha)
Patch connection (red) = 5 acres (2 ha)

Study zone 5

Township 14
Range 14
West of 1st meridian

Prairie restoration (blue) = 42 acres (17 ha)
Patch connection (red) = 5 acres (2 ha)



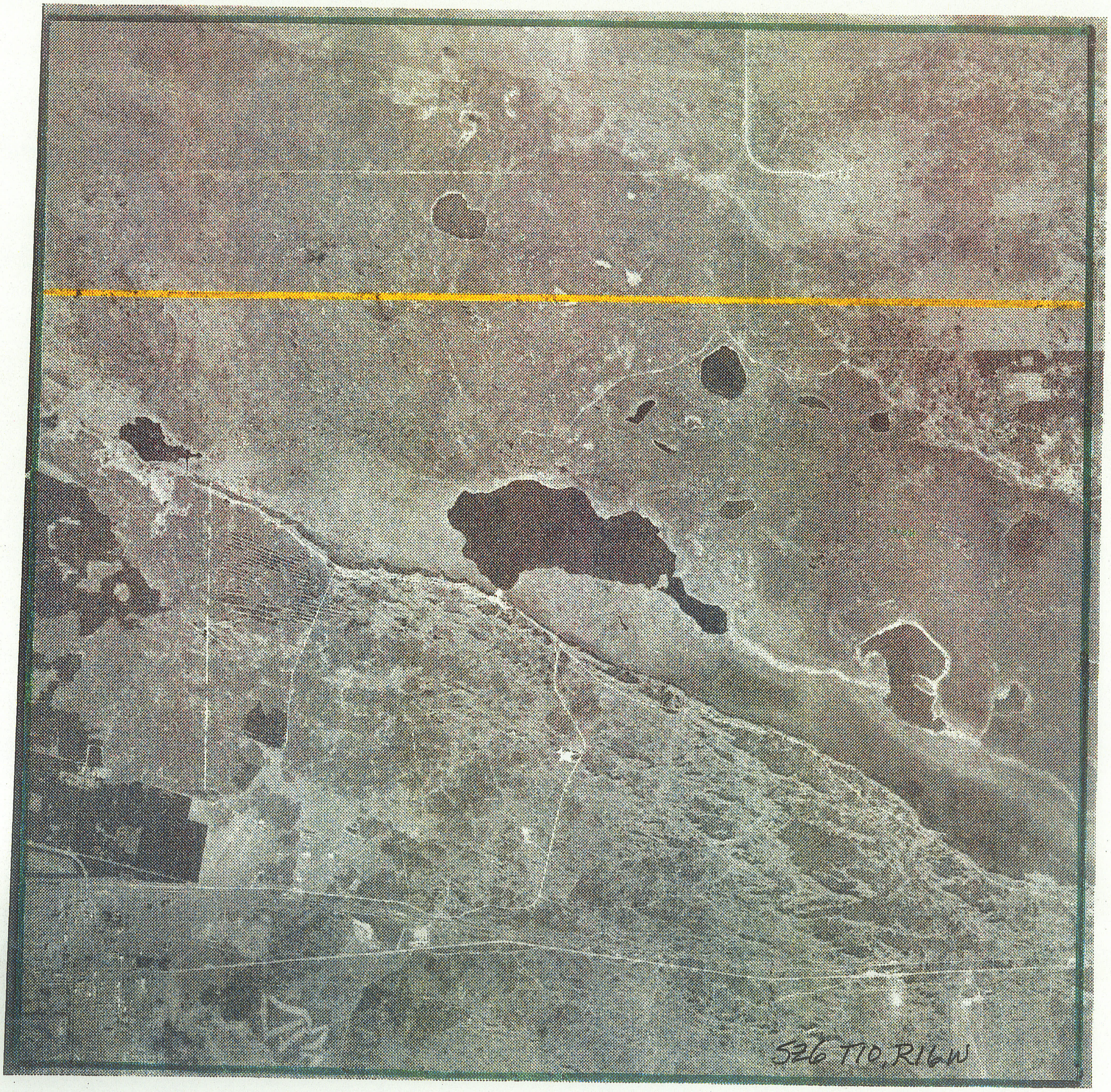
Study zone 5

Township 14
Range 15
West of 1st meridian

Prairie restoration (blue) = 27 acres (10.9 ha)
Patch connection (red) = 3 acres (1.2 ha)

Study zone 6

Township 10
Range 16
West of 1st meridian



Study zone 6

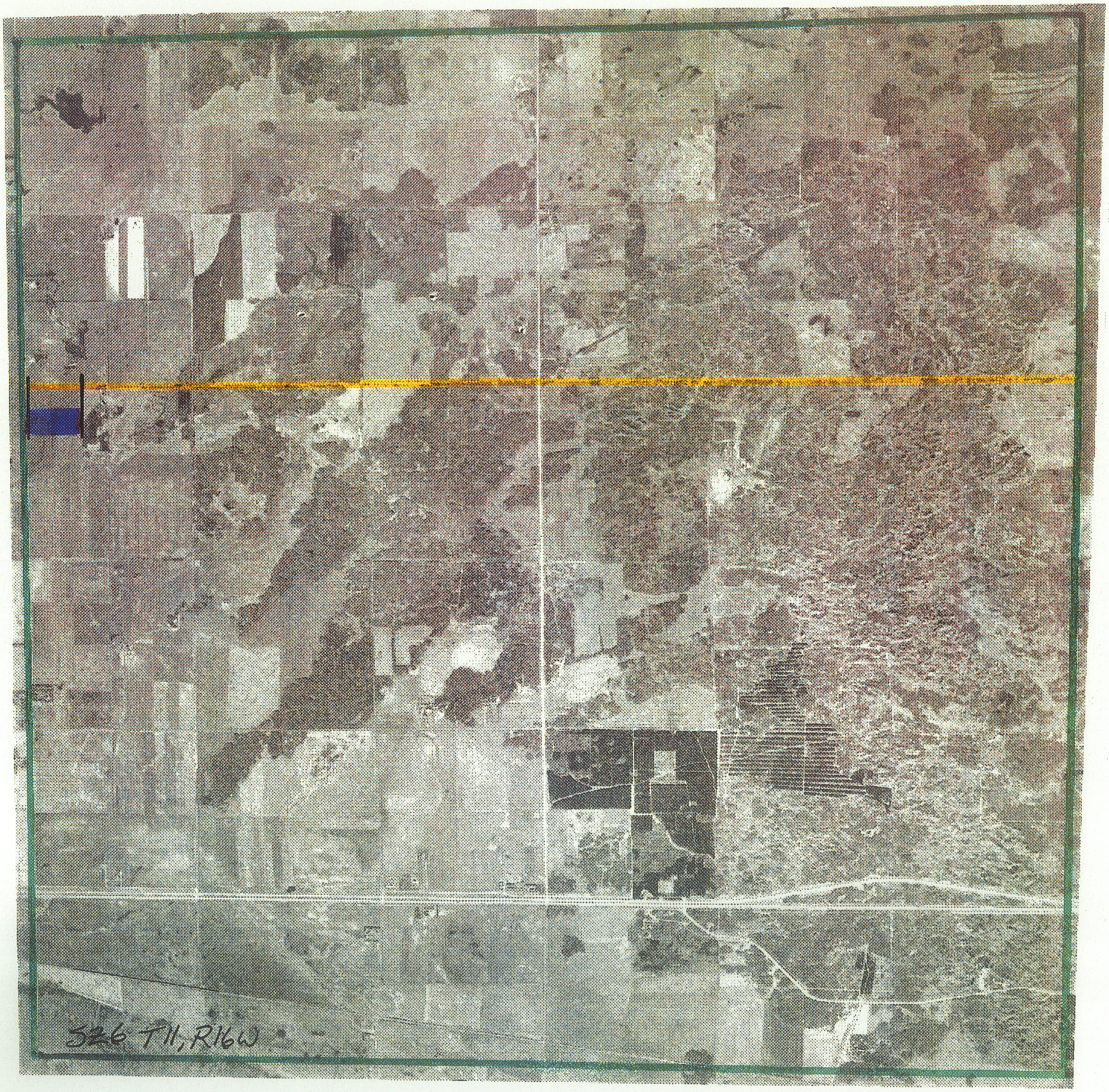
Township 10
Range 17
West of 1st meridian

Patch connection (red) = 3 acres (1.2 ha)

Study zone 6

Township 11
Range 16
West of 1st meridian

Prairie restoration (blue) = 4 acres (1.6 ha)



Study zone 6

Township 11
Range 17
West of 1st meridian

Prairie restoration (blue) = 46 acres (18.6 ha)