BOREAS
Experiment Plan

Chapter 2
Experiment Design and Project Organization

May 1994 Version 3.0

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2.0 EXPERIMENT DESIGN AND PROJECT ORGANIZATION

2.1 Overview of Approach

The experimental approach was determined by the objectives as stated in Chapter 1. The overall goals of the project and some of the subsidiary objectives emphasize the need to study the biome's biophysical, chemical and ecological functioning under different conditions. The governing climatological variables controlling these in the biome are temperature (associated with length of growing season, radiation budget, etc.) and moisture availability (associated with precipitation, snow hydrology and surface hydrological processes). Essentially, the northern ecotone of the forest is delineated by temperature (growing degree days) while the southern boundary is determined by moisture stress and fire frequency in central and western Canada, and by ecological competition with temperate deciduous forest to the east of the Great Lakes. Most global change scenarios predict warming and drying in the mid-continent. A minimum of two intensive study areas is therefore desirable as this would allow the observation of processes associated with the controlling factors (temperature in the north, moisture in the south) which are most likely to undergo significant change within the biome as a whole.

Each study area covers a domain big enough to allow the acquisition of useful airborne flux measurements and satellite observations but small enough to permit reasonable coverage with surface instruments. It is anticipated that almost all of the land surface climatology, nutrient cycling and tropospheric chemistry process studies (i.e. flux towers and other flux measurement efforts) and most of the remote sensing validation work will be conducted within these areas, see figures 2.1.1.2a and b. Ecological survey and remote sensing studies may also require some sampling within the whole domain along and normal to the growing degree day isolines (roughly corresponding to the productivity gradient) with particular concentration within and around the main sites. The definition and allocation of the auxiliary/process study sites is directed at defining the variability of surface states and processes and associated remote sensing signatures within and between the main sites. The distance between the two study areas is roughly 600 km: this is large enough to resolve the ecological gradient but small enough to permit the ferrying of research aircraft and specialized equipment between sites.

2.1.1 Multiscale Strategy

2.1.1.1 Hierarchy of Spatial Scales

The measurement strategy in BOREAS is to link the findings of process studies conducted at very small scales to regional-scale effects, see Figure 2.1.1.1a. A hierarchical set of spatial scales has been defined for the project in order to organize the available measurement and analysis resources

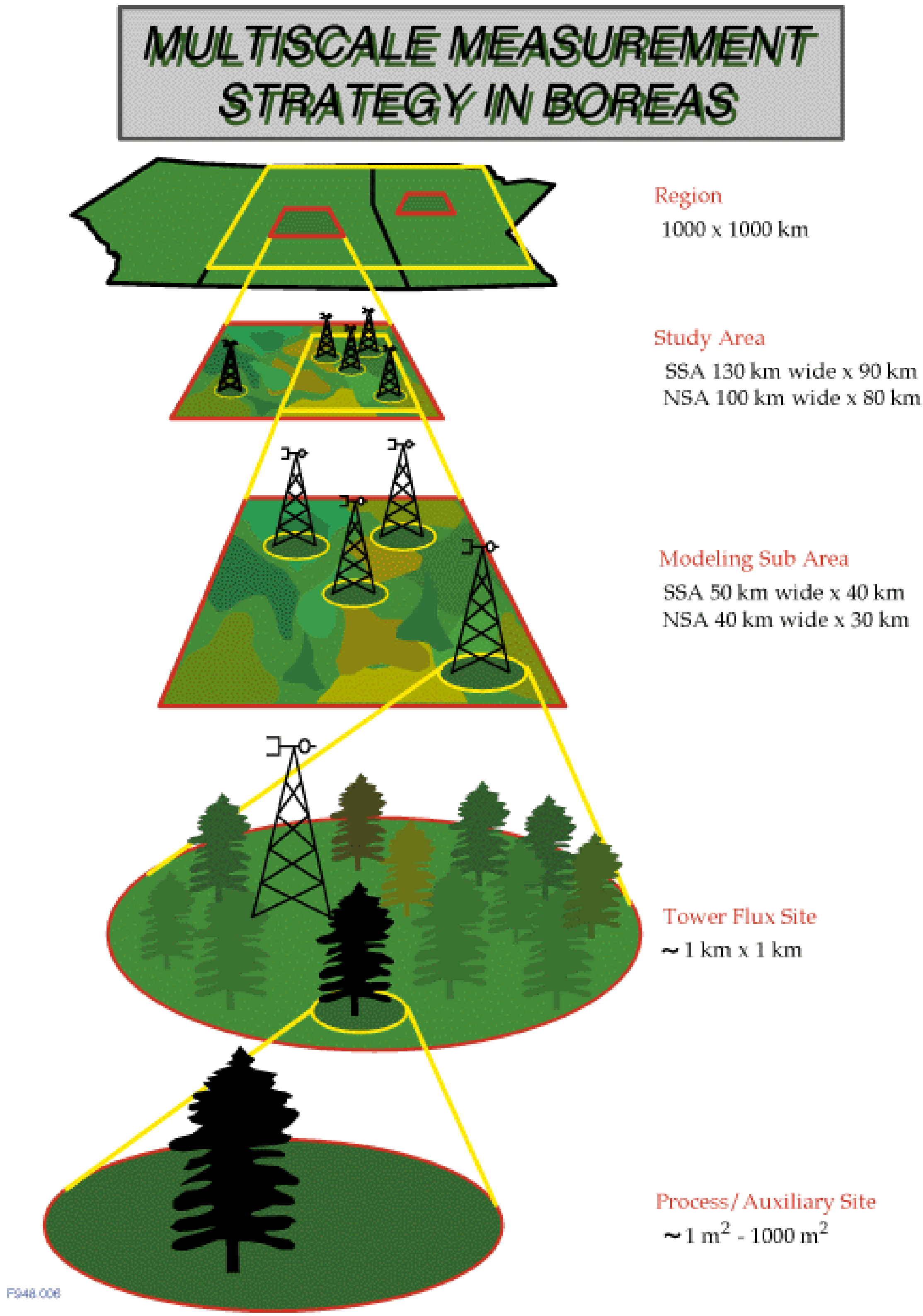


Figure 2.1.1.1a Multiscale Measurement Strategy in BOREAS

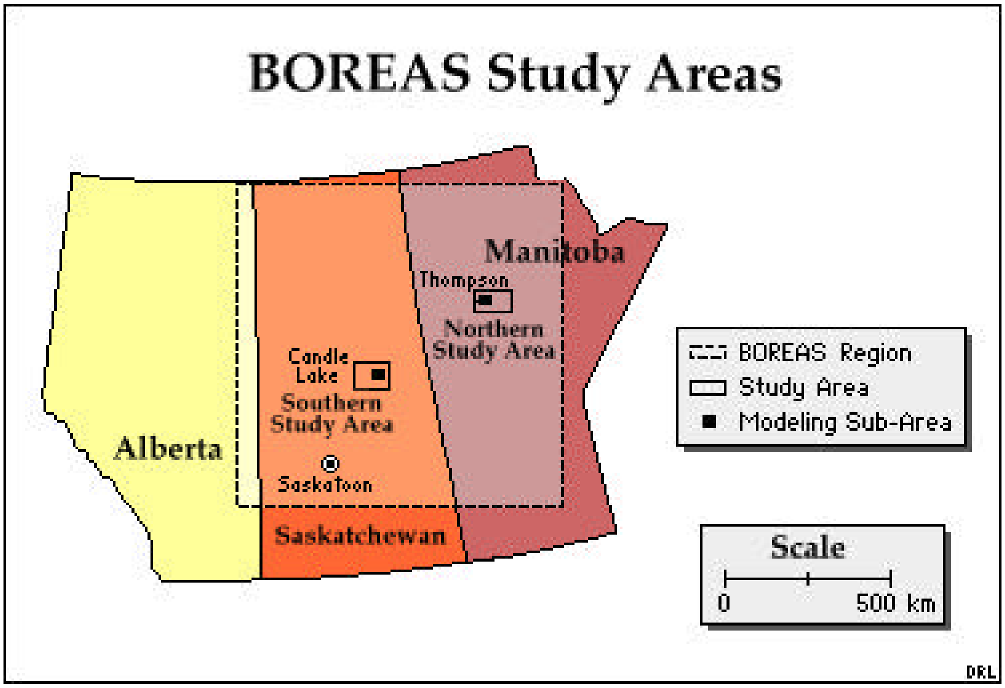


Figure 2.1.1.1b Location of BOREAS Region showing locations of the Northern and Southern Study Areas and the modeling sub-areas

Table 2.1.1.1
Hierarchy of Research Domains in BOREAS; See also Figure 2.1.1.1a

Domain	Size (W x L)	No	Purpose	Name
Region	1000 km x 1000 km	1	Domain of meteorological surface network and augmented upper air sounding network; coarse resolution satellite data acquisition and large-scale modeling	BOREAS Region
Study Areas	SSA: 130 km x 90 km NSA: 100 km x 80 km	2	Focus of intensive satellite/airborne remote sensing, meteorological measurements, hydrological studies and airborne flux measurements	Southern Study Area (SSA) Northern Study Area (NSA)
Transect	TBD ~400km x 30 km	1	Area connecting and including the NSA and SSA	BOREAS Transect
Modeling Sub Area	SSA: 50 km x 40 km NSA: 40 km x 30 km	2	Testing ground for modeling activities and gridded data products	NSA Modeling Sub Area SSA Modeling Sub Area
				Northern Study Area (NSA)
Tower Flux Sites	1 km x 1 km	9	Measurement of fluxes over representative cover types. Foci for detailed remote sensing studies and process studies	Old Black Spruce (NSA-OBS) Old Jack Pine (NSA-OJP) Young Jack Pine (NSA-YJP) Fen (NSA-Fen)
				Southern Study Area (SSA)
				Old Aspen (SSA-OA) Old Black Spruce (SSA-OBS) Old Jack Pine (SSA-OJP) Young Jack Pine (SSA-YJP) Fen (SSA-Fen)
Process Study Sites and	$\geq$ 1m x 1 m		Process study sites are to be used for ecological and trace gas, biogeochemistry field work	Process Study Sites
Auxiliary Sites	100m x 100m	~80	Auxiliary sites are to be used as remote sensing and biometry validation targets.	Auxiliary Sites

Table 2.1.1.1 Hierarchy of Research Domains in BOREAS;

efficiently. The scale domains of this hierarchy are defined below and are expanded on in Table 2.1.1.1.

Region: An area of roughly 1000 km by 1000 km covering a large portion of Saskatchewan and Manitoba. Domain of meteorological and satellite data acquisition and large-scale modeling, see Figure 2.1.1.1b and section 3.2.

Study Areas: Two areas embedded within the region. These will be the focus of satellite and airborne remote sensing studies, airborne flux measurement and mesoscale modeling. Two study areas have been specified for BOREAS: The Southern Study Area (SSA) (11,170 km^2) around Prince Albert, Saskatchewan, and the Northern Study Area (NSA) (8,000 km^2) near Nelson House/Thompson, Manitoba.

Transect: Area connecting and including the NSA and SSA.

Modeling Sub Areas: Testing ground for modeling activities and gridded data products. These areas have the highest priority for remote sensing studies and low-level airborne flux measurements.

Tower Flux (TF) Sites: These are sites within the study areas where flux measurement towers operate. The TF sites are located in the center of areas of around 1 km^2 of homogenous vegetation cover, and are expected to measure fluxes representative of these vegetation types. Nine TF sites will operate during the IFCs, see Sections 2.2.3 and 4.2.

Auxiliary and Process Study Sites: Around 80 auxiliary and process study sites, some located within the TF sites, most of the others elsewhere within the study areas, are to be used for investigator studies or correlative targets for remote sensing investigations, see Section 3.2.4. The geographic coordinates for these sites are shown in Table 3.5.3.6.

2.1.1.2 Study Area Locations and Mesometeorological Network

The original BOREAS Science Steering Committee conducted the initial study area selection in 1990; see Sellers et. al. (1991), (section 3.0, plus Appendices) for details. This work was followed up by BOREAS staff visits in 1991, 1992 and 1993. Table 2.1.1.2 contains coordinates for the corners of the study and modeling sub areas. The finalized study areas are:

Northern Study Area: An area of 8000 km^2, located between Thompson Manitoba and Nelson House Manitoba. Highway 391 runs through the center of the area. Four tower flux (TF) sites are located within the area, see Figure 2.1.1.2a.

	Corner	BORIS Grid		Geographic		UTM NAD 83			UTM NAD 27	
	Point	Y	X	Latitude	Longitude	Northing	Easting	Zone	Northing	Easting
Northern	NW	650	750	56.247	-98.82	6233565	510884	14	6233340	510902
Study	NE	650	850	56.081	-97.24	6216458	609930	14	6216232	609518
Area	SE	570	850	55.377	-97.49	6137770	595766	14	6137545	595785
	SW	570	750	55.540	-99.05	6154889	497150	14	6154664	497168
NSA	NW	630	760	56.055	-98.72	6211970	517312	14	6211958	517330
Modelling	NE	630	800	55.990	-98.09	6205124	556757	14	62051113	556776
Sub-Area	SE	600	800	55.726	-98.18	6175619	551608	14	6175608	551626
	SW	600	760	55.790	-98.18	6182466	512162	14	6182455	512180
Extension	NW	615	750	55.938	-98.92	6198930	504876	14	6198918	504894
of NSA	NE	615	760	55.922	-98.76	6197218	514737	14	6197206	514755
Modelling	SE	605	760	55.834	-98.79	6187383	513020	14	6187372	513038
Sub-Area	SW	605	750	55.849	-98.95	6189095	503159	14	6189084	503177
Southern	NW	380	310	54.319	-106.23	6019734	420187	14	6109510	420218
Study	NE	380	440	54.223	-104.24	6008564	549799	14	6008324	549828
Area	SE	290	440	53.419	-104.37	5919013	542029	14	5918792	542061
	SW	290	310	53.513	-106.32	5930178	412468	14	5929954	412500
SSA Sub-	NW	360	380	54.093	-105.18	5993612	488258	14	5993606	488287
Modelling	NE	360	430	54.053	-104.42	5989312	538103	14	5989306	538132
Area	SE	320	430	53.695	-104.48	5949512	534652	14	5949507	534682
	SW	320	380	53.735	-105.23	5953813	484815	14	5953807	484845

Based on NAD 1983 datum unless otherwise specified.

Table 2.1.1.2 Coordinates of study areas and modeling subareas.

Southern Study Area: For the Southern Study Area, it proved to be difficult to find extensive stands of the required cover types grouped together in one locale. As a result, the five TF sites are distributed over the area of Prince Albert National Park through to the Candle Lake and surrounding area covering a total area of 11170 km^2, see figure 2.1.1.2b.

Details on the appropriate locations and cover types for the TF sites are given in Section 2.2.3.

Mesometeorological Network: To address the scaling issues discussed in Chapter 1, it is necessary that a mesoscale meteorological network be put in place around and between the two study areas, i.e., covering the region. This consists of a few atmospheric profiling/sounding rigs and some surface meteorological stations arranged so as to allow the estimation of the advection and divergence terms of important scalars over the study areas via data assimilation into atmospheric models, see Figure 2.1.1.2c, section 3.2.1 and section 3.2.2.

2.1.2 Duration and timing of field operations.

The measurement of fluxes at or near the surface and of radiances and emittances above the surface necessitates the use of sophisticated airborne and surface equipment. A subset of some surface flux (tower-mounted) equipment will operate almost continuously through the experimental period; that is from late 1993 through late 1994, together with an appropriate low-intensity ecological, hydrological and meteorological measurement program. However, the operation of the bulk of the surface equipment and almost all of the airborne sensors is expensive in terms of manpower and money and cannot be sustained for long periods. Additionally, there is a strong need to obtain contemporaneous observations of all the appropriate parameters. These facts favor concentrating the intensive observational efforts at as few sites as possible and also for conducting a series of intensive field campaigns (IFCs) with time in between for rest and refurbishing equipment. These campaigns are to be embedded in a longer term monitoring effort carried out using satellites and automatic instrumentation on the surface.

The field phase of the experiment planned for 1993 and 1994 is shown in Table 2.1.2 and figure 2.1.2.

A 'shakedown' Intensive Field Campaign (IFC-93) has taken place over three weeks in August 1993. This had the primary objective of ironing out problems with equipment and operational procedures (planning,

BOREAS Northern Study Area (NSA)

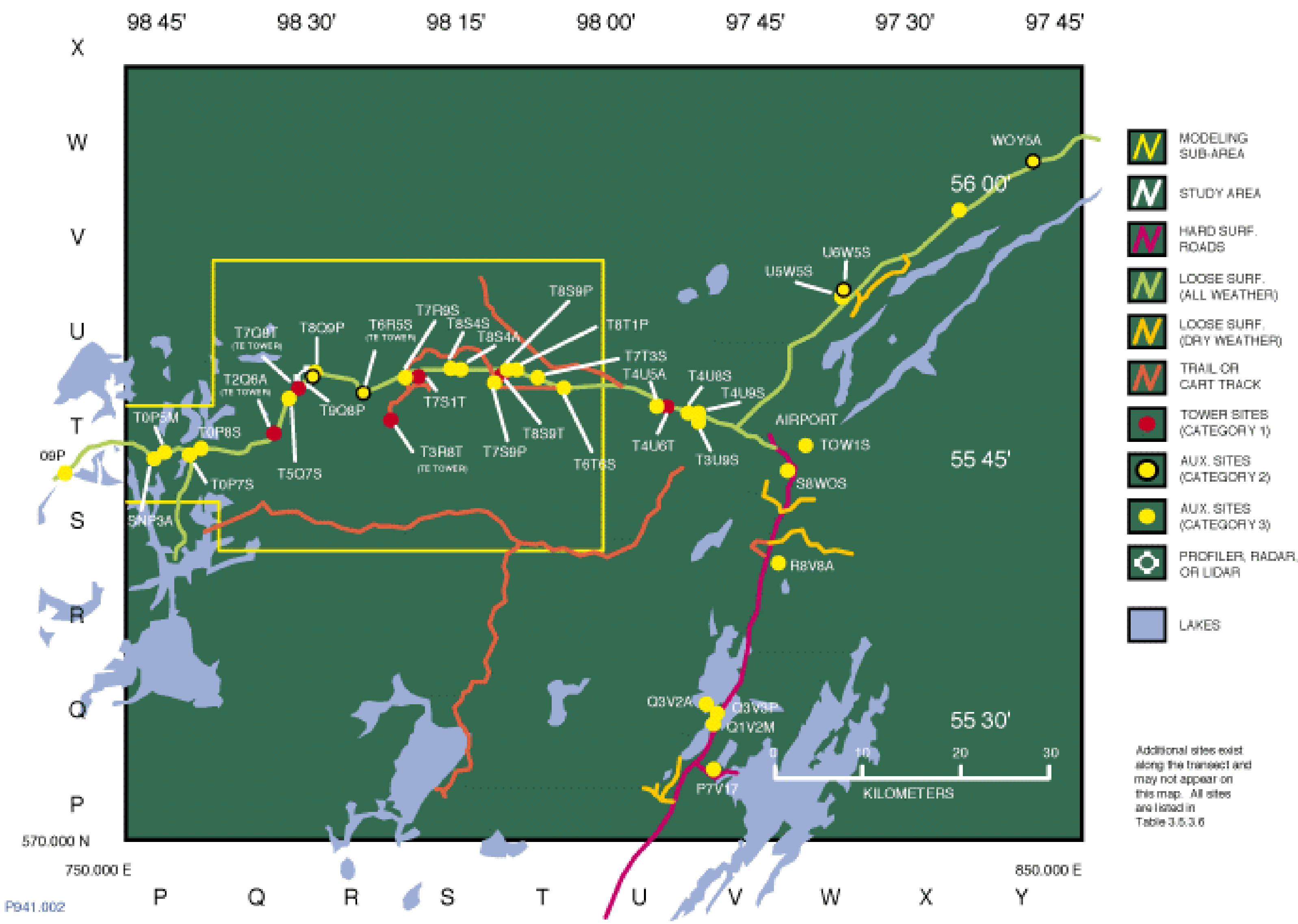


Figure 2.1.1.2a Northern Study Area, showing location of Tower Flux (TF) sites and some auxiliary sites. Explanation of the coordinate system and naming conventions for sites may be found in 3.5.4.

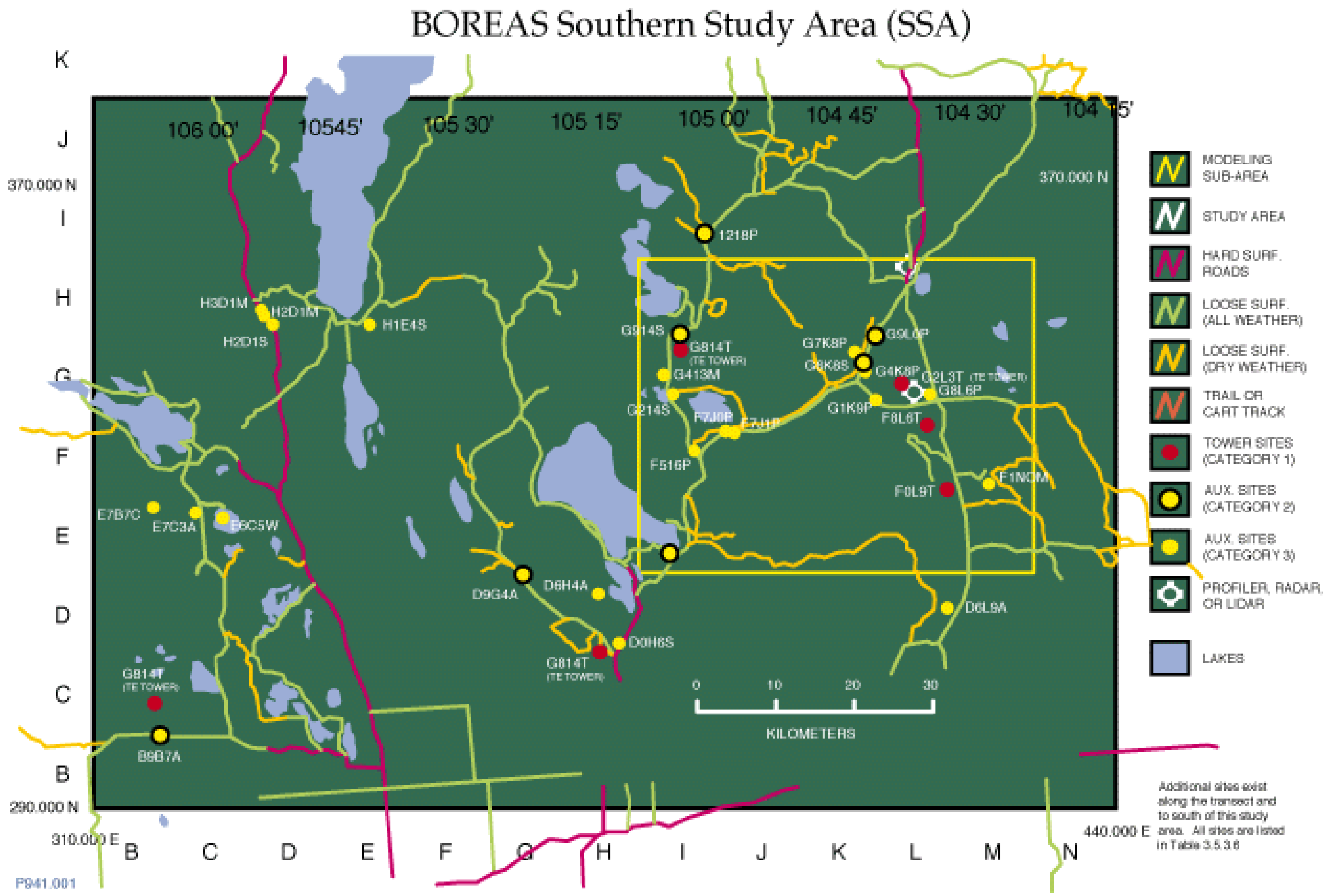


Figure 2.1.1.2b Southern Study Area showing Tower Flux (TF) sites and some auxiliary sites. Explanation of the coordinate system and naming conventions for sites may be found in 3.5.4.

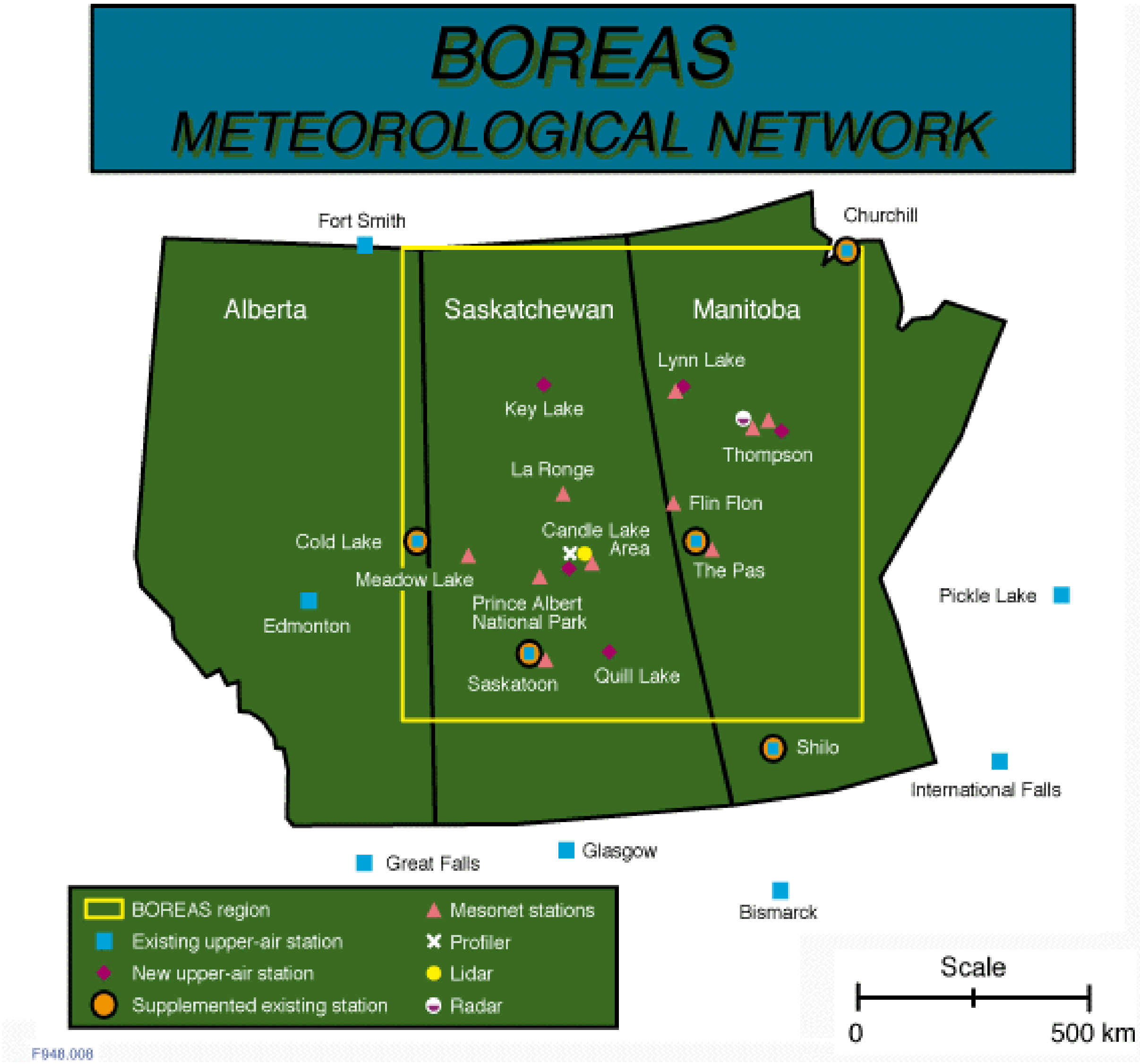


Figure 2.1.1.2c The mesoscale meteorological network, upper-air meteorological network and the additional terrestrial ecology sites, see also sections 3.2.1 and 3.2.2.

Table 2.1.2
Dates, durations, activities and aircraft associated with BOREAS field campaigns for 1993 and 1994.

	Start Date	End Date	Duration (days)	Activities	Aircraft
IFC -93	8/9/93 221	8/29/93 241	21	Shakedown	DC-8, LongEZ
FFC-W	2/1/94 32	2/16/94 49	16	Snow hydrology and remote sensing ~ 10 teams.	ER-2, Chieftain, Aerocommander, Twin Otter (M)
FFC -T	4/12/94 102	5/2/94 122	21	Thaw hydrology and remote sensing ~25 teams.	DC-8, ER-2, C-130, CV-580, Chieftain
IFC-1	5/24/94 144	6/16/94 167	24	Maximum effort. All field teams.	DC-8, ER-2, C-130, Helo, Chieftain, Flux Aircraft (4)
IFC-2	7/19/94 200	8/8/94 220	21	Maximum effort. All field teams.	DC-8, ER-2, C-130, Helo, Chieftain, CV-580, DC-3 Flux Aircraft (4) Aerocommander.
IFC-3	8/30/94 242	9/19/94 262	21	Maximum effort Most field teams.	DC-8, ER-2, C-130, Helo, Chieftain, Flux Aircraft (4) Aerocommander

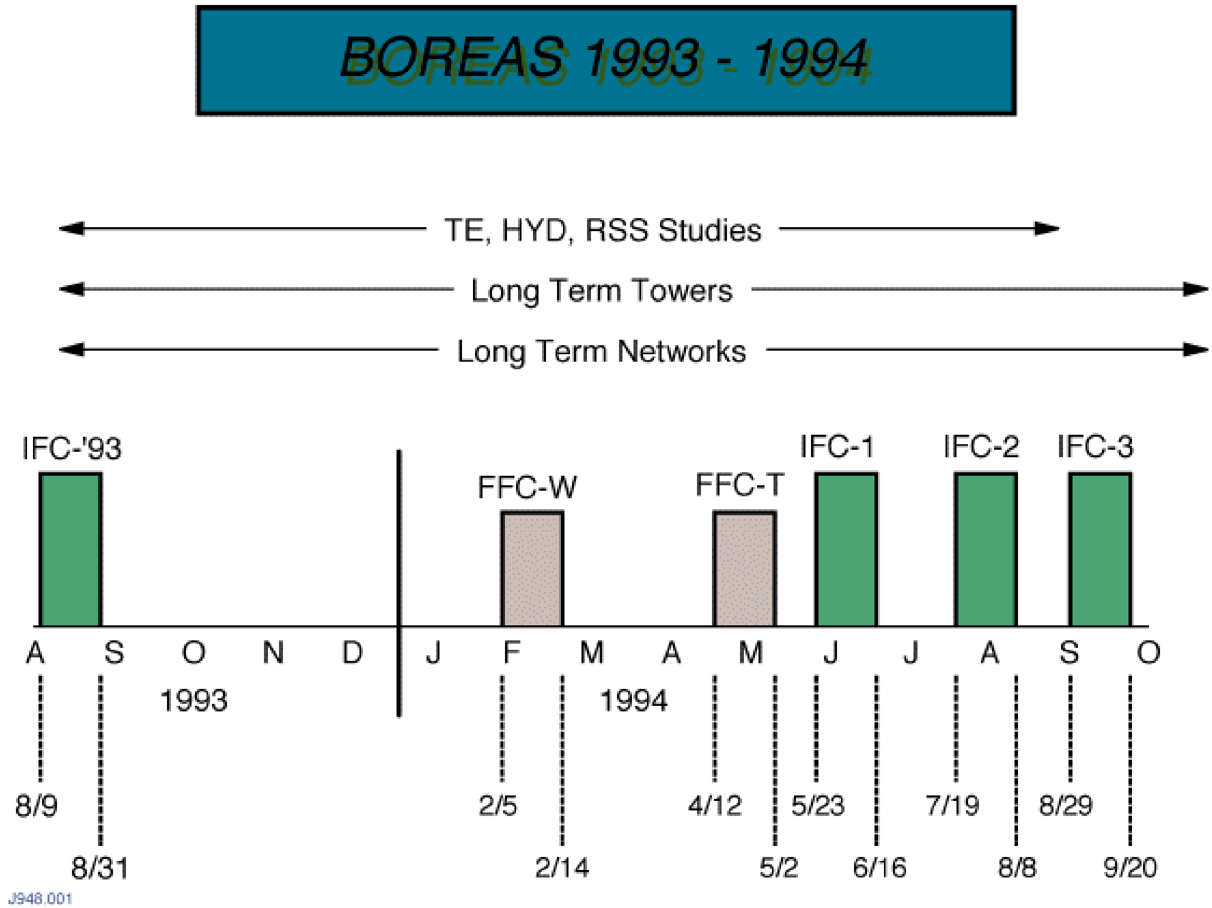


Figure 2.1.2 Proposed timing of field campaigns in the 1993-1994 timeframe.

communications, coordination). Most of the monitoring activities were initiated at this time.

The calendar year of 1994 is the main field year for BOREAS. Two Focused Field Campaigns (FFCs) concentrate on processes associated with snow hydrology and remote sensing in the winter (FFC-W) and thaw period (FFC-T). There will be three IFCs during the growing season during which most of the sophisticated equipment and aircraft will be in the field. It is planned that the bulk of the TF sites will take data from the beginning of IFC-1 through the end of IFC-3.

Monitoring and a subset of field activities will continue through 1995. In 1996, there may be a return to the field to fill in data gaps and to follow-up on questions raised in the analysis of the 1994 data set. The analysis phase of the project will extend into at least 1996 and almost certainly for several years thereafter.

2.2 Study Areas and Tower Flux Sites

2.2.1 Sampling Strategy

The total number of Tower Flux (TF) measurement rigs is a limiting resource to the project. Initially, it was desired that the TF sites be located to sample across the following strata, in order of priority:

Climate:	Near northern and southern ecotones
Vegetation Type:	Coniferous, deciduous, fen
Age:	Young, old
Hydrology:	Wet and dry
Treatment:	Unburned, burned, logged

It became clear that there would not be enough resources to cover all strata in a rigorous way. It also became clear that it would be difficult to locate TF sites close together within the Southern Study Area (SSA) owing to the lack of suitable sites to be found within any given locale. Access, power and resupply considerations played an important role in determining the final set of TF sites.

Section 2.2.3 describes the TF site locations and attributes in some detail. In summary, the site allocation covers the first two strata classes satisfactorily (climate, vegetation type); the next two sparsely (age, hydrology); and the last one inadequately (treatment).

2.2.2 Study Areas

The study areas are shown in Figures 2.1.1.2a and b. A brief summary of the attributes of each area is provided below.

2.2.2.1 Northern Study Area (Thompson, Manitoba)

The NSA is 100 km wide x 80 km (Figure 2.1.1.2a). By road, Thompson is 735 km from Winnipeg, 525 km from The Pas and 385 km from Flin Flon. Driving distance to Candle Lake (SSA Headquarters) is about 780 km. It is quite typical of the extreme northern boreal forest. It is gentle in terrain, contains few lakes and is covered primarily with black spruce, scattered birch and some stands of jack pine. Stand ages are variable, up to 80 years old. Trees are smaller in stature than in the SSA. There is very little aspen, occurring only in very small patches. The NSA is accessible by an all-weather gravel road (highway 391) connecting Thompson and Nelson House. Several gravel pit roads and winter access trails to a power line to the south of highway 391 provide additional access. Thompson itself is a town of roughly 15 000 in population with adequate motel and other facilities.

Ecological Setting: The NSA is close to the northern limit of the closed-crown boreal forest. Situated on low-relief terrain and with soils predominantly derived from Glacial Lake Agassiz sediments, the area represents a northern version of the black spruce, jack pine and aspen forests that characterize the low relief plains in the south. Evidence of its nordicity is: 1) the scarcity of balsam fir and white spruce, except along streams; 2) widespread prevalence of white birch, which to a large extent replaces aspen; and 3) the occasional incidence of "cold terrain" features such as thermokarst peat plateaus and boulder fields (felsemeer). Mixed woods of spruce-aspen-pine typical of the southern boreal forest of this region are absent. As well, the open-crown subarctic lichen woodland is close to the north indicating closeness to a significant climate-soil discontinuity.

Vegetation: The predominant species is black spruce which occurs in stands of varying density. It occurs in bogs, drier lichen covered sites and occasional rock outcrops. There are some jack pine stands mainly in the south and west parts of the study area. The kame deposits have closed to open stands of mainly pure jack pine with other species occurring on patches of clay or beach deposits. Forest stands are generally mature with some being over 100 years old. Heights vary from stunted black spruce in bogs areas to stands as tall as 15m. White birch and trembling aspen are scattered within some of the coniferous stands; pure stands are rare and small. Forest cover is broken by varying density, moisture conditions and especially open treed bogs. Stands and uniform patches are small. No logging has occurred in the study area.

Fire History: A large 1981 burn is in the southern part of the area and a large 1964 burn with predominantly jack pine regeneration is situated near the eastern boundary. Large 1989 burns occur in the western and northern sections of the study area.

Physiography: The NSA site lies within the Canadian Shield Province. In northwestern Manitoba it has a gently rolling surface with numerous small lakes.

Surficial Geology: Most of the region is composed of clay deposited by glacial Lake Agassiz. In low areas, the surficial deposits are mostly varved clays. The deposits are thin or absent in the higher areas. Also in the low lying areas bogs and fens exist. Permafrost can often be found a few feet below the surface of bogs. Permafrost can also occur at greater depths in clay soils on thickly wooded slopes and some ridges. Two major hills composed of sand and gravel (kame deposits) run in a north-south direction with relief up to 60m.

Bedrock Geology: The underlying bedrock consists of Pre-Cambrian gneissic granite which has been glacially polished.

Landforms: The terrain is flat and broadly rolling in low regions and hilly in the high areas. The two kame deposits are an exception and may have local relief up to 60m. The upper portions were reworked by the shoreline of Lake Agassiz and exhibit ancient strand lines.

Soils: The soils are predominantly derived from Glacial Lake Agassiz sediments and consist of clays, organics and some sandy deposits. Soil depths vary from bare rock outcrops on the top of hills to deep sedimentation basins in the low areas up to 17m thick. Within the NSA boundary are two kame deposits forming ridges running approximately N-S. They consist of sandy gravelly deposits that were reworked by Lake Agassiz wave action and exhibit ancient shore lines along the top of the hills. There are occasional outcrops of bedrock. Variations in moisture regimes occur due to topography or soil changes. There are some areas of discontinuous permafrost.

Topography: The topography reflects the glacially smoothed Pre-Cambrian bedrock surface which has been only minimally modified by glacial drift. Terrain is of low relief (mostly less than 15m). It is gentler in the north. Several narrow stream valleys have a relief of 25m. There are some outcrop knolls. Two kame deposits are within the site with local relief up to 60m.

Hydrology: Being flat and having abundant wetland areas, the drainage of much of the area is poor. There are several significant streams that flow into the Sapochi and Odei Rivers and the few lakes within the area are small. There are some large lakes (2x15 km) to the north and northwest of the area. Bog and fen occur on most of the low-lying terrain. Permafrost occurs a few feet below the surface of the bogs. It also occurs at a greater depth under thickly wooded slopes of some clay mantled ridges.

Accommodation and Laboratory Facilities: Accommodation is available in Thompson (hotels, motels and single rooms in a community college); details are given in the Appendix. Laboratory (wet and dry) facilities are available at 192 Hayes Road (see section 3.4.2) during FFC-T and IFC's, see Patrick Crill or Dan Hodkinson for details. Operations planning meetings will be held in the INCO Training Center, see also Section 5.1. Operations will be managed from the Study Area Headquarters (SAHQ) located in the Keewatin Air hangar at the airport.

Airport Information: The airport in Thompson (YTH) is equipped with two runways, NAVAIDS and an on-site flight service station. The longest runway (05-23) is asphalt and is 5800 feet long. Several aircraft and helicopter charter companies are based out of Thompson. Three airline companies offer daily connections to and from Winnipeg. There are several connections a week to and from Flin Flon.

Background Map Data: Topographic Maps at 1:50 000 and 1:250 000 are available over the study area. Forest cover data for 1969 and 1991 at 1:15840 and 1:63 360 have been developed from black and white aerial photography (1:15 840). A 1:250 000 scale Land Systems map covers the region. Soil survey work will be carried out as part of BOREAS and for scaling purposes, a 1:250,000 soils map will be developed for the NSA, see Section 3.2.3.3. Surficial and bedrock geology has been mapped at 1:250 000. Contact BORIS for information on sources of maps.

2.2.2.2 Southern Study Area (Prince Albert, Saskatchewan)

The Southern Study Area (SSA; Figures 2.1.1.2b) is 130 km wide by 90 km. The southern boundary can be reached within 40 km north from the town of Prince Albert (PA). PA is a moderately sized town with adequate accommodations and airport facilities. The SSA topography is gentle, with a relief 550m to 730m. Soils range from gray wooded to degraded black classified as brunisolic, gleysolic, chernozemic, luvisolic and organic soil orders. The surficial deposits vary in thicknesses from 100m to 1000m on top of the Cretaceous Age bedrock. The western part of SSA is in the Prince Albert National Park (PANP) and the eastern region falls within and around the Narrow Hills Provincial Forest. The PANP land is managed by the Canadian Parks Service. There are two major vegetation zones in the study area,the mixed wood section of the boreal forest region and the aspen grove section.

Ecological Setting: The PANP area is characterized by aspen and spruce uplands, black spruce and tamarack bogs, jack pine ridges, sedge meadows and fescue grassland outliers. White spruce is also common and balsam fir occurs in minor quantities. The SSA is near the southern limit of the boreal forest; transition to natural prairie grassland occurs 15 km to the southeast. The agricultural transition occurs to the south of the PANP boundary. The eastern section of the study area is in the mixed wood section of the boreal forest zone. Around Candle Lake, mixed woods composed of aspen and white spruce are common where the sites are well drained. Jack pine-black spruce exist around the Torch River Plain with pure stands of jack pine on dry sites composed of coarse textured soils. In the poorly drained areas throughout the study area, bogs support black spruce with some tamarack. The fen areas are composed mostly of sedge vegetation with discontinuous cover of tamarack or swamp birch.

Vegetation: There are two major vegetation groups consisting of the Boreal Forest and aspen groves. The site within the PANP boundary is characterized by aspen and spruce uplands, black spruce and tamarack bogs, jack pine ridges, sedge meadows and fescue grassland outliers. Ages commonly range between 50-100 years. Heights typically range from 15 to 22m, although there are stunted black spruce in bog areas. Some areas are characterized by small (10-30m) holes in the canopy due to local wet sites. There are large patches of aspen and to a lesser extent jack pine and black spruce and patches of uniform inhomogeneity. Forest cover is often controlled by small changes in relief and soil/soil drainage. Aspen occurs on the uplands, jack pine on minor ridges and black spruce in the lower poorly drained sites. There has been no logging or fires in PANP since the 1940s.

To the east of PANP the vegetation is classified as mixed boreal forest. On well drained and or sandy soil the predominant species is jack pine. Poorly drained sites support black spruce. Mixed stands of aspen and white spruce are found on well drained glacial deposits. Localized logging occurs by fence post operators and by Weyerhaeuser.

Fire History: Within the southern half of the PANP there were fires during 1940-1949 over the central region. West of Bittern Lake there was a fire in 1969. In the NE section of the Study Area the Fishing Lakes burn occurred in 1977-1978. South of Bittern Lake and West of Montreal Lake there was a fire in 1989. Overall, recent fires have been limited in extent and frequency through a comprehensive forest fire suppression program.

Physiography: The SSA site lies within the Saskatchewan Plains Region of the Great Plains Province of North America with elevations ranging from 400 to 700m. There are several sections including the Waskesiu Hills Upland, Wapawekka Hills Upland, White Gull Creek Plain, Montreal Lake Plain and the Spruce River Plain.

Surficial Geology: The surface deposits are of Pleistocene or Recent age. The Pleistocene deposits are of glacial origin. These deposits are in the form of till, glaciolacustrine or lacustrine, and glaciofluvial or outwash materials with thicknesses from 100 to 400m. Glacial till deposits are shallower in the lowlands and in the depression where Candle Lake is located. The glacial drift is undifferentiated; mainly gray, calcareous till. It also contains gray, calcareous, gravel, sand, and silt; and clay that weathers to an olive or brown color. Organic deposits of Recent Age were formed after the glacial period.

Bedrock Geology: Directly beneath the surficial deposits are the Lea Park formation, Upper Colorado Group, Ashville-Lower Colorado Group and the Swan River Group, all of Cretaceous age. The bedrock topography has a surface that has been glacially eroded as indicated by its broad, featureless, gently undulating nature.

Landforms: The landforms consist of glacial till plains, and rolling or hilly moraines. They are of glaciofluvial, glaciolacustrine, fluvial lacustrine, alluvial and aeolian origin.

Soils: The soils have developed on thick glacial deposits. The region consists of glacial till, glaciolacustrine and glaciofluvial material of Late Wisconsin age and recent organic deposits. Soils range from gray wooded to degraded black with brunisolic, gleysolic, chernozemic, luvisolic and organic soil orders.

Topography: The Saskatchewan Plains is an area of gentle relief. The region has elevations ranging from 400 - 700m. The Waskesiu Hills Upland and the Wapawekka Hills upland are roughly undulating, often ridged or fluted, till plain. The White Gull Creek Plain is a gently undulating to moderately rolling outwash plain. Fluvial lacustrine sands, sometimes reworked into sand dunes, are the most common surficial deposits.

Hydrology: Most of the study area is located within the Saskatchewan River drainage system. In the PANP, the Spruce & Sturgeon Rivers connect to the Saskatchewan River near the town of Prince Albert. In the middle of the study area, Candle Lake is a depression at the headwaters of the Torch River which drains the surrounding area. Intertill aquifers are common and are composed of up to 200 feet of fine to coarse-grained sand. A few surficial aquifers are present in gravel deposits but most are in interbedded fine to medium-grained sand and silt. Aquifers occur in these sediments where the sand beds are sufficiently extensive and thick.

Accommodation and Laboratory Facilities: Accommodation is available in Prince Albert and Candle Lake. Some investigators may be staying near Waskesiu although this places them some additional distance from the center of the experiment at Candle Lake. Details on accommodations can be found in the Appendix. There are good laboratory facilities (wet and dry lab) at the Paddockwood School, Paddockwood. Details may be obtained from Betsy Middleton (US), see also section 3.4.2. Operations will be managed from the Snodrifters Lodge in Candle Lake.

Airport Information: The Prince Albert airport (YPA) has an asphalt runway (08-26) 5000 feet long, NAVAIDS and an on-site flight service station. The Saskatoon airport (YXE), 140 km by road south of Prince Albert, has an asphalt runway, 8300 feet long. There are scheduled flights three days per week between Prince Albert and Saskatoon. In Prince Albert, there are two airline charter companies and two helicopter charter companies. Scheduled air service between Regina or Saskatoon and Prince Albert varies depending on time of year and economic conditions.

Background Map Data: Topographic maps are available at 1:50 000 and 1:250 000. Surficial geology was mapped at 1:250 000 and bedrock geology at 1:1 000 000. There are two separate sets of data for forest cover information and soils. The PANP forest cover data, soils, and plant community association were mapped at 1:50 000 for the PANP Biophysical Resource Inventory (1978). Forest cover data outside of PANP is available at 1:12 500 and the soils at ~1:125 000. Further soil characterization work will be carried out in BOREAS, see Section 3.2.3.3. Contact the BORIS data Manager for information on sources of maps.

2.2.3 Tower Flux Sites

Section 2.2.3.1 and 2.2.3.2 contain preliminary data of the tower flux sites at the NSA and SSA. Information about the NSA fen and SSA fen was provided by the tower flux teams. Data for the treed tower sites was collected by BOREAS staff in the following methods. Final tower locations are not at the exact proposed spots where the reproduced data were collected.

Data collected for ecological descriptions of the treed tower sites: Two different techniques were used to characterize the forests around each of the tower sites. The purpose of this characterization was to provide investigators with preliminary data concerning diameter and total tree height, species composition and canopy density. On any particular site, this numerical description can be used as a guide to canopy homogeneity around the tower.

The first sampling technique involved the partition of a 1000m x 1000m area centered on the proposed tower location into as many as five homogeneous strata using high resolution, stereo, aerial photography. One prism point was purposefully located in each stratum in an area which typified that stratum using the aerial photography. The following data were collected at each point: dbh, species, crown position (dominant, codominant, intermediate, suppressed) and at a given point: 4 canopy density measures, total height and height to live crown of 2 randomly selected codominant trees, age at breast height of those trees, and comments. A rapid understory assessment was made to describe ground cover and shrub species. On a 5 x 5 m fixed area plot centered on the stratum sample point, Daubenmire percent cover classes were assigned to the following land cover categories: 5 most abundant shrubs, 5 most abundant herbs, mosses, lichens, slash, rock and standing water. The Daubenmire classes follow: 1 = 0-5%, 2 = 5-25%, 3 = 25-50%, 4 = 50-75%, 5 = 75-95%, 6 = 95-100%.

This assessment was done quickly by walking about the 5 x 5m site; only coarse estimates of percent cover were needed for each of the 15 land cover classes.

This single point characterization of each stratum allowed us to estimate mean forest canopy attributes, but the process says nothing about tree canopy variability and continuity. In fact, this type of purposive sampling avoids cover type features which would induce or suggest variation, e.g., holes in the canopy. Since canopy continuity must be addressed in the tower site selection process, a second sampling approach was used to quantify canopy density variability.

Three line transects, at 270˚(median wind vector), 20˚ and 160˚, each 300m to 500m long, were walked. The proposed tower site served as the origin. Canopy density was characterized every 50 meters along the transect and at points three meters on either side of the 50m mark along the transect. Four spherical densiometer observations were averaged at each point to develop canopy closure estimates. The four canopy density observations were made by rotating the densiometer in 90 degrees increments over the sample point.

The diameter, species and crown position (dominant, codominant, intermediate, suppressed) of each tree whose canopy lies directly above each 50m point was also recorded. Unlike the prism points, the diameter of all trees whose canopies directly overlie a given point was measured; there was no minimum diameter requirement. These canopy counts may be used to develop a relatively rigorous estimate of average canopy closure and the variance of that estimate for the area surrounding the tower. Also, ground cover conditions were noted at each 50m point.

The selected tower flux (TF) sites are listed in Table 2.2.3 together with the assigned Principal Investigators/Site Captains. Further information on the TF measurements may be found in Chapter 4.

Table 2.2.3
Tower Flux Site Location and
*Site Captains (same as Table 4.2.3.1a)

Project #	Principal Investigator	Cover Type	Site_ID	Study Area	Site Maps
TF-3	Wofsy*	Old Black Spruce	T3R8T	NSA	4.2.3.2a
TF-8	Fitzjarrald*	Old Jack Pine	T7Q8T	NSA	4.2.3.2b
TF-10	McCaughey*/*Jelinski	Young Jack Pine	T8S9T	NSA	4.2.3.2c
TF-10	Jelinski*/LaFleur*	Fen	T7S1T	NSA	4.2.3.2d
TGB-4	Roulet*	Beaver Pond	T4U6T	NSA	4.2.3.2e
TF-1	Black/Thurtell	Old Aspen	C3B7T	SSA	4.2.3.2f
TF-2	den Hartog*	Old Aspen	C3B7T	SSA	4.2.3.2f
TF-4	Anderson*	Young Jack Pine	F8L6T	SSA	4.2.3.2g
TF-5	Baldocchi*	Old Jack Pine	G2L3T	SSA	4.2.3.2h
TF-6	Bessemoulin*	Young Aspen	D6H4T	SSA	4.2.3.2i
TF-7	Desjardins	Old Black Spruce	G8I4T	SSA	4.2.3.2j
TF-9	Jarvis*	Old Black Spruce	G8I4T	SSA	4.2.3.2j
TF-11	Verma*	Fen	F0L9T	SSA	4.2.3.2k
HYD-5	Harding*	Namekus Lake and Clear cut	E7B7C	SSA	4.2.3.2l

* = Site Captain

Summaries of attributes of each TF site are provided within the following two subsections (2.2.3.1 and 2.2.3.2).

2.2.3.1 Northern Study Area Tower Flux Sites

Site Name	Abbreviation	Site_ID
Old Jack Pine	NSA-OJP	T7Q8T
Old Black Spruce	NSA-OBS	T3R8T
Fen	NSA-Fen	T7S1T
Young Jack Pine	NSA-YJP	T8S9T

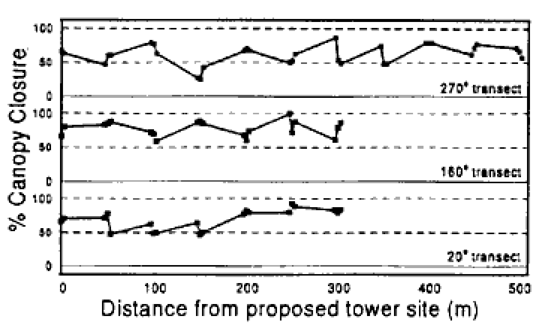
Northern Study Area — Old Jack Pine (NSA-OJP)

BOREAS Grid: (x = 768.5, y = 617.1)
Lat/Long: 55.927° N, -98.62° W • UTM Zone 14, N: 6,197,997 E: 523,501

	Primary stratum	Secondary stratum	Tertiary stratum
Stratum name	Jack Pine/Pinus banksiana	Jack Pine with black spruce	Deciduous
Overstory Vegetation Properties			
Common names	Jack pine	Jack pine with black spruce	Paper birch
Scientific names	*Pinus banksiana*	*P. banksiana/Picea mariana*	*Betula papyrifera*
Stem Density (Live stems/ha)	1875	3102	1323
Basal Area (m^2/ha)	9.1	16	20
Age (years)	58	40 - 65	46 - 51
Height (m)	9	8 - 11	13 - 14
Understory Vegetation Properties			
Common names	vacant	Alder/black spruce	Alder 10% cover
Scientific names		*Alnus crispa/P. mariana*	*Alnus crispa*
Ground Cover Vegetation Properties			
Common names	Lichen dominated	Mosses	Variety of herbs/mosses
Scientific names	*Cladina spp*	*Pleurozium spp, Ptillium spp*	*Pyrola spp/Lycopodium spp*

Soil Properties

Drainage	Well	Imperfectly	Well
Texture	Wells sorted sandy outwash	30 cm outwash over lake clay	Well sorted fine sand
Available Water Holding Capacity	Low	Low/high	Moderate
Depth of organic layer (cm)	< 5	10	< 8
Soil series	Brunisol	Brunisol	Brunisol



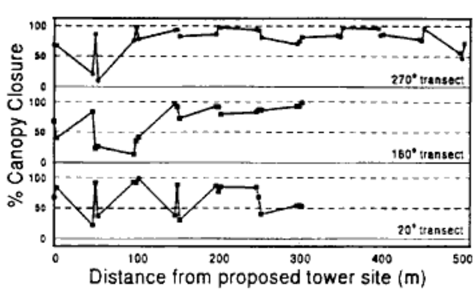
Transect Data		
Bearing	**% Closure ($\bar{X} \pm s$)**	**Transect length (m)**
270°	62 ± 15	500
160°	78 ± 11	300
20°	70 ± 15	300

PRELIMINARY DATA ONLY: READ SECTION 2.2.3

Northern Study Area — Old Black Spruce (NSA-OBS)

BOREAS grid: (x=778.1, y= 613.3)
Lat/Long: 55.879˚ N, -98.48˚ W • UTM Zone 14, N:6.192,700 E:532,301

	Primary stratum	Secondary stratum	Tertiary stratum
Stratum name	Spruce/feather moss	Spruce, sphagnum	Patchy/wet
Overstory Vegetation Properties			
Common names	Black spruce/some balsam poplar with a few jack pine and aspen	Black spruce	Black spruce, larch, few aspen, balsam poplar
Scientific names	*Picea mariana/Populus balsamifera with Pinus banksiana and Populus*	*P. mariana*	*P. mariana, Larix laricina/few P. tremuloides P. balsamifera*
Stem Density (Live stems/ha)	900	600	not taken
Basal Area (m^2/ha)	12	24	not taken
Age (years)	75	90	not taken
Height (m)	9 - 12	5 - 9	2 - 10
Understory Vegetation Properties			
Common names	10% over black spruce	Vacant	Willow/dwarf birch
Scientific names	*P. mariana*	Vacant	*Selix spp./Betula glandiosa*
Ground Cover Vegetation Properties			
Common names	85% cover feather and reindeer moss; with labrador tea, bog cranberry and other herbs	Sphagnum 80%, labrador tea 50%, reindeer moss 10%, trace of willow	Sedges/sphagnum/ Labrador tea /honeysuckle/grasses
Scientific names	*Hylocomium spp; Ledum groenlandicum/Vaccinum vitis-idaea*	*Sphagnum spp, L. groenlandicum, Cladina spp, salix spp*	*Sphagnum spp/Ledum groenlandicum/Lonicera involucrata, Calamagrostis*
Soil Properties			
Drainage	Well	Poor to very poor	Very poor
Texture	Clay	Clay and moss peat over clay	Sedge peat over clay and clay
Available Water Holding Capacity	High	High	High
Depth of organic layer (cm)	< 5	20 - 100	40 - 120+
Soil series	Orthic grey luvisol and orthic lutric brunisol	Peaty phase orthic gleysol and terric fibrisol. Probably some permafrost	Mesisol and peaty phase orthic gleysol with permafrost



Transect Data		
Bearing	**% Closure (X ± s)**	**Transect length (m)**
270°	78 ± 21	500
160°	70 ± 29	300
20°	67 ± 25	300

PRELIMINARY DATA ONLY: READ SECTION 2.2.3

Northern Study Area — Fen (NSA-Fen)

BOREAS grid: (x=781.2, y= 617.9)

Lat/Long: 55.914° N, -98.42° W • UTM Zone 14, N:6.196,703 E:536,103

	Primary stratum	Secondary stratum	Tertiary stratum
Stratum name	Birch	Tamarack/Spruce	n/a
Overstory Vegetation Properties			
Common names	Bog birch	Tamarack, Black Spruce	n/a
Scientific names	*Betula pumila*	*Larix laricina, Picea Mariana*	*n/a*
Stem Density (Live stems/ha)	n/a	n/a	n/a
Basal Area (m^2/ha)	n/a	n/a	n/a
Age (years)	n/a	n/a	n/a
Height (m)	0.8	1 - 4	n/a
Understory Vegetation Properties			
Common names	Buckbean, sedges, cottongrass	n/a	n/a
Scientific names	*Menyanthes trifoliata, Corex rostrate, Eriophorum augustifolium*	n/a	*n/a*
Ground Cover Vegetation Properties			
Common names		n/a	n/a
Scientific names		*n/a*	*n/a*

Soil Properties

Drainage	Very poor	Very poor	n/a
Texture	Peat	Peat	n/a
Available Water Holding Capacity	High	High	n/a
Depth of organic layer (cm)	100 - 350	n/a	n/a
Soil series	Typic and Humic Mesisols	n/a	n/a

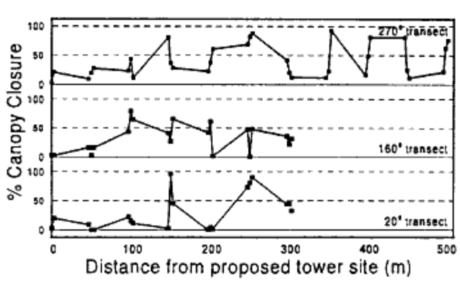
The fen is approximately 2.5 km long and .75 km wide. Water pH and conductivity are high, indicating a high nutrient status typical of rich-fen systems. Water pH ranges from 6.6 to 7.1 and conductivity from 150-250 mS; however, the pH in the hollows is around 5.4 with corresponding low conductivity. Vegetation in the lagg, which borders much of the fen includes a variety of aquatic marophytes such as *Lemna minor, Caltha palustris, Pedicularis parvifloras* and *Ranunculus flabelaris* in the deeper portions and *Carex* spp. and *Salix* spp. on the border. The fen surface has widely-spaced *Larix laricina* ranging in height from 1-2.5 m dominating the overstory. *Betula glandifera* of 0.8 m height comprises the upper layer of the understory. Ground cover consists primarily of *Menyanthes trifoliata, Carex rostrata,* and *Eriophorum augustifolium*. Other common species include *Rumex* spp., *Potentilla palustris* and *Stellaria* spp. Water-filled hollows are dominated by *Hippuris vulgaris*. The dominant bryophyte species on the hummocks is *Sphagnum warnstorf.* In the hollows, the dominant bryophyte is *Tomenthynum nitens.* The soils are typic and humic mesisols. The tend to be shallow (1.0 m) near the lagg and 2.5-3.5 m thick near the fen's center. Unfrozen mineral soil lays beneath most of the peat. [Descriptions provided by Dennis Jelinski]

Northern Study Area — Young Jack Pine (NSA-YJP)

BOREAS grid: (x=789.6, y= 618.2)

Lat/Long: 55.903° N, -98.29° W • UTM Zone 14, N:6.195,502 E:544,498

	Primary stratum	Secondary stratum	Tertiary stratum
Stratum name	Jack pine regeneration	Jack pine with tall black spruce	Jack pine with short black spruce
Overstory Vegetation Properties			
Common names	vacant	Jack pine with few paper birch/aspen	Jack pine scattered aspen
Scientific names		*P. banksiana, Betula papyrifera/Populus tremuloides*	*P. mariana, Larix laricina*
Stem Density (Live stems/ha)	42000 (understory)	23000	5700
Basal Area (m^2/ha)	< 0.1 (understory)	30	10
Age (years)	< 25 (understory)	20 - 25	80
Height (m)	0 - 2.5 (understory)	3 - 5	4 - 6.5
Understory Vegetation Properties			
Common names	Jack pine	Black spruce, choke cherry and alder	vacant
Scientific names	*Pinus banksiana*	*Picea mariana, Padus nana* and *Alnus crispa*	*P. mariana, Larix laricina*
Ground Cover Vegetation Properties			
Common names	Jack pine, lichen, slash, bare ground, much litter	50% leaf litter, 20% dead fall, 15% bog cranberry, 10% labrador tea	> 90% Sphagnum and feather moss, 60%
Scientific names	*P. banksiana, Cladina spp*	*Vaccinium vitis-idaea, Ledum groenlandicum*	*Sphagnum spp, Hylocomium spp*
Soil Properties			
Drainage	very rapid	well to imperfectly drained	well to imperfectly
Texture	coarse sand to sandy	sand and gravel over clay	sand and gravel over clay
Available Water Holding Capacity	Low	Low	Low
Depth of organic layer (cm)	< 3	3 - 25	15 -100
Soil series	eluviated dystric brunisol	eluviated and gleyed eluviated dystric brunisols and peaty phase orthic gleysols, perched water table	peaty phase orthic gleysols



Transect Data

Bearing	% Closure (X ± s)	Transect length (m)
270°	41 ± 27	500
160°	35 ± 24	300
20°	32 ± 33	300

PRELIMINARY DATA ONLY: READ SECTION 2.2.3

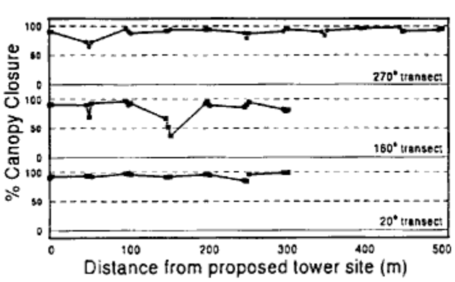
2.2.3.2 Southern Study Area Tower Flux Sites

Site Name	Abbreviations	Site_ID
Old Aspen	SSA-OA	C3B7T
Old Black Spruce	SSA-OBS	G8I4T
Old Jack Pine	SSA-OJP	G2L3T
Young Jack Pine	SSA-YJP	F8L6T
Fen	SSA-Fen	F0L9T
Young Aspen	SSA-YA	D6H4T

Southern Study Area — Old Aspen (SSA-OA)
Prince Albert National Park (PANP)

BOREAS grid: (x=317.3, y= 303.4)
Lat/Long: 53.629° N, -106.20° W • UTM Zone 13, N:5.942,694 E:420,843

	Primary stratum	Secondary stratum	Tertiary stratum
Stratum name	Mature Aspen/Corylu	Balsam poplar/Corylus	Open, wet mix-wood, patchy
Overstory Vegetation Properties			
Common names	Aspen with a few balsam poplar	Balsam poplar, some quaking aspen, few paper birch	White spruce, balsam poplar, and scattered alder
Scientific names	*Populus tremuloides with P. balsamifera*	*P. balsamifera, P. tremuloides, Betula papyrifera*	*Picea glauca, P. balsamifera, alnus crispa*
Stem Density (Live stems/ha)	900	344	325
Basal Area (m^2/ha)	22	16	26
Age (years)	60		40, 58
Height (m)	21	12 - 19	15
Understory Vegetation Properties			
Common names	Hazelnut (60%) Wildrose (15%)	Hazelnut (45%) Wildrose (25%)	Hazelnut
Scientific names	*Corylus cornuta, Rosa woodsii*	C. comuta, R. woodsii	*C. cornuta*
Ground Cover Vegetation Properties			
Common names	50% leaf litter, variety of herbs, grasses	50% leaf litter, variety of herbs, grasses	90% leaf litter, variety of herbs, small woody stems
Scientific names	n/a	n/a	n/a
Soil Properties			
Drainage	Well to moderately well	Well to imperfect	Very poorly
Texture	Loam to clay loam till	Loam to clay loam till	Mesic sedge peat over clay-loam till
Available Water Holding Capacity	High	High	High
Depth of organic layer (cm)	< 8	0 - 15	to 1 m
Soil series	Orthic gray aluvisols	Orthic gray aluvisols with glade orthic gray aluvisols and luvic glysols	Terric mesosol



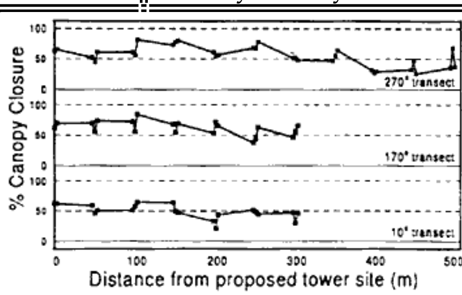
Transect Data		
Bearing	**% Closure ($\bar{X} \pm s$)**	**Transect length (m)**
270°	90 ± 8	500
160°	83 ± 16	300
20°	94 ± 4	300

PRELIMINARY DATA ONLY: READ SECTION 2.2.3

Southern Study Area — Old Black Spruce (SSA-OBS)

BOREAS grid: (x=384.8, y= 348.4)
Lat/Long: 53.985° N, -105.12° W • UTM Zone 13, N:5.981,904 E:492,000

	Primary stratum	Secondary stratum	Tertiary stratum
Stratum name	Spruce/feather moss	Spruce, sphagnum	n/a
Overstory Vegetation Properties			
Common names	Black spruce with some jack pine and tamarack	Black spruce with some tamarack	n/a
Scientific names	*Picea mariana/ with Pinus banksiana Larix laricina*	*Picea mariana with Larix laricina*	*n/a*
Stem Density (Live stems/ha)	4330	3710	n/a
Basal Area (m^2/ha)	30	10	n/a
Age (years)	up to 155 (black spruce) 110 (jack pine)	95 at breast ht (spruce) (probably up to 150+)	n/a
Height (m)	0-10 (black spruce) 13 (jack pine) 10 - 16 (tamarack)	0 - 6 (black spruce) 4 + (tamarack)	n/a
Understory Vegetation Properties			
Common names	1-5% black spruce	15% black spruce	n/a
Scientific names	*P. mariana*	P. mariana	*n/a*
Ground Cover Vegetation Properties			
Common names	feather moss with labrador tea	Sphagnum moss with feather moss & bog cranberry	n/a
Scientific names	*Pieurozium schreberi* *Hylocomium splendens*	*Sphagnum fuscum* *Pieurozium schreberi* *Vaccinium vitis-idaea*	*n/a*
Soil Properties			
Drainage	Imperfect to poor	Poor to very poor	n/a
Texture	Sandy loam/loam till	Peat	n/a
Available Water Holding Capacity	Moderate	High	n/a
Depth of organic layer (cm)	5 - 20	50 - 60 some 100 - 120	n/a
Soil series	Gleyed Gray Luvisol	Terric Msisol	n/a



Transect Data		
Bearing	**% Closure ($\bar{X} \pm s$)**	**Transect length (m)**
270°	55 ± 15	500
160°	62 ± 11	300
20°	49 ± 11	300

PRELIMINARY DATA ONLY: READ SECTION 2.2.3

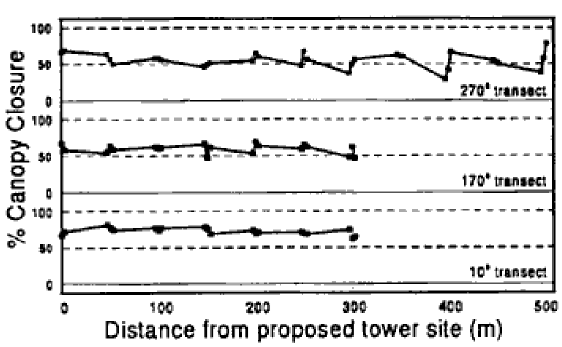
Southern Study Area — Old Jack Pine (SSA-OJP)

BOREAS grid: (x=413.6, y= 343.2)
Lat/Long: 53.916° N, -104.69° W • UTM Zone 13, N:5.974,022 E:520,285

	Primary stratum	Secondary stratum	Tertiary stratum
Stratum name	Old Jack Pine	Old Jack Pine	none sampled
Overstory Vegetation Properties			
Common names	Jack Pine	Jack Pine	
Scientific names	*Pinus banksiana*	*Pinus banksiana*	
Stem Density (Live stems/ha)	1320	1380	
Basal Area (m^2/ha)	33	25	
Age (years)	60 - 75	60 - 75	
Height (m)	12 - 15	11 - 15	
Understory Vegetation Properties			
Common names	Green alder 0-20%	Green alder 0-25%	
Scientific names	*Alnus crispa*	Alnus crispa	
Ground Cover Vegetation Properties			
Common names	bearberry, feather moss, lichens	lichens, feather moss, bearberry	
Scientific names	*Arctostaphylos uva-ursi* *Pieurozium schreberi* *Cladina*	*Cladina* *Pieurozium schreberi* *Arctostaphylos uva--ursi*	

Soil Properties

Drainage	very well		
Texture	sandy		
Available Water Holding Capacity	low		
Depth of organic layer (cm)	10 - 15		
Soil series	Degraded Eutric Brunisol		



Transect Data		
Bearing	**% Closure ($\bar{X} \pm s$)**	**Transect length (m)**
270°	56 ± 10	500
160°	60 ± 6	300
20°	72 ± 5	300

PRELIMINARY DATA ONLY: READ SECTION 2.2.3

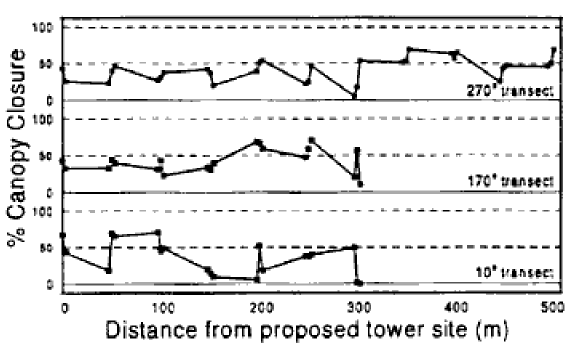
Southern Study Area — Young Jack Pine (SSA-YJP)

BOREAS grid: (x=416.9, y= 338.9)
Lat/Long: 53.875° N, -104.65° W • UTM Zone 13, N:5.969,705 E:523,201

	Primary stratum	Secondary stratum	Tertiary stratum
Stratum name	Regenerating Jack Pine	none sampled	none sampled
Overstory Vegetation Properties			
Common names	Jack Pine		
Scientific names	*Pinus banksiana*		
Stem Density (Live stems/ha)	4056		
Basal Area (m^2/ha)	9.1		
Age (years)	11 - 16		
Height (m)	4 - 5		
Understory Vegetation Properties			
Common names	vacant		
Scientific names	vacant		
Ground Cover Vegetation Properties			
Common names	Grasses, Bearberry, lichens		
Scientific names	*Graminoids, Arctostaphylos uva-ursi, Cladina spp.*		

Soil Properties

Drainage	very well		
Texture	sandy		
Available Water Holding Capacity	low		
Depth of organic layer (cm)	10 - 15		
Soil series	Degraded Eutric Brunisol and Orthic Eutric Brunisol		



Transect Data		
Bearing	**% Closure ($\bar{X} \pm s$)**	**Transect length (m)**
270°	4 ± 15	500
160°	43 ± 16	300
20°	36 ± 23	300

PRELIMINARY DATA ONLY: READ SECTION 2.2.3

Southern Study Area — Fen (SSA-Fen)

BOREAS grid: (x=419.5, y= 330.6)
Lat/Long: 53.799° N, -104.62° W • UTM Zone 13, N:5.961,204 E:525,101

	Primary stratum	**Secondary stratum**	**Tertiary stratum**
Stratum name	Fen	Strings	Flarks
Overstory Vegetation Properties			
Common names	Bog Birch	Tamarack, Black spruce	Vacant
Scientific names	*Betula pumilla*	*Larix laricina*	*n/a*
Stem Density (Live stems/ha)	n/a	n/a	n/a
Basal Area (m^2/ha)	n/a	n/a	n/a
Age (years)	n/a	n/a	n/a
Height (m)	1	2 - 5	n/a
Understory Vegetation Properties			
Common names	Sedges, Buckbean, Willow	Bog birch	Buckbean, aquatic plants
Scientific names	*Carex spp., Eriophorum spp., Menyanthes trifoliate, Salix spp.*	Betula pumilla	*Menyanthes trifoliate*
Ground Cover Vegetation Properties			
Common names	Mosses, 50% open water	Sedges, mosses	Open water
Scientific names	*non-Sphagnum*	*Carex spp., non-Sphagnum*	*n/a*

Soil Properties

Drainage	Very poor	Very poor	Very poor
Texture	Peat	Peat	Peat
Available Water Holding Capacity	High	High	High
Depth of organic layer (cm)	50 - 200	50 - 300+	50 - 100
Soil series	Typic Mesisol	Humic Mesisol	Fibric Mesisol

The tower-flux fen site is located one km west of highway 106, 40 km north of Seaton. The fen is approximately 500 m wide (east-west) and 2 km long (north-south). The instrument tower is located 50 m from the eastern edge in the southern part of the fen. This is a patterened fen. Near the tower the strings (higher, drier areas) are predominantly of bog birch (*Betula pumila)* 1-1.5 m tall with a few strings of tamarack (*Larix laricina)* 2-4 m tall. The northern part of the fen is dominated by strings of tamarack 3-5 m tall. The flarks (lower, wetter areas free from woody plant species) have buckbean *(Menyanthes trifoliata)* as a common vegetation. The strings and flarks are oriented perpendicular to the hydrologic flow which is from north to south. The peat soil surface consists of hollows covered with various species of mosses (no *Sphagnum*), and hummocks, which in addition to some moss cover, are densely covered with *Carrex* and *Eriophorum* sedges and possibly others. *Andromedea* is also present. The typic and humic mesisol peat soils are 2-3 m thick in the center of the fen and 1 m thick around the edge.

Southern Study Area — Young Aspen (SSA-YA) Torch Lake

BOREAS grid: (x=374.8, y= 316.7)
Lat/Long: 53.709° N, -105.31° W • UTM Zone 13, N:5.951,000 E:479,400

	Primary stratum	Secondary stratum	Tertiary stratum
Stratum name	Young Aspen	Hardwood softwood mix	Hardwood softwood mix
Overstory Vegetation Properties			
Common names	Aspen	White Spruce, Aspen, Balsam Poplar	Aspen, Balsam fir
Scientific names	*Populus tremuloides*	*Picea glauca, P. tremuloides, P. balsamea*	*P. tremuloides P. balsamea*
Stem Density (Live stems/ha)	2353	2400	5372
Basal Area (m^2/ha)	16	21.8	17.2
Age (years)	14 - 24	15 - 52	95
Height (m)	6 - 12.5	8 - 19	21
Understory Vegetation Properties			
Common names	Balsam fir (6%) Hazelnut (15%)	Balsam fir (5%) Wildrose (15%)	Balsam fir (5%) Wildrose (5%)
Scientific names	*Abiea balsamea, Cornus canadensis*	Abies balsamea, Rosa sp.	*Abies balsamea, Rosa sp.*
Ground Cover Vegetation Properties			
Common names	n/a	n/a	n/a
Scientific names	*n/a*	*n/a*	*n/a*

Soil Properties

Drainage	Moderately well to imperfectly	restricted	well
Texture	Silt loam to gravally loamy sand	Medium textured glacial till	Medium textured glacial till
Available Water Holding Capacity	High	High	High
Depth of organic layer (cm)	n/a	n/a	n/a
Soil series	Brunisolic Grey Luvisol	Brunisolic Grey Luvisol	Brunisolic Grey Luvisol

PRELIMINARY DATA ONLY: READ SECTION 2.2.3

2.3 **Project Organization**

The selected BOREAS investigators have been organized into Science Teams, see Section 4. These are responsible for conducting most of the innovative science in BOREAS. The support for the project (logistics, BORIS, etc.) is provided by the BOREAS staff, some of whom also carry out supporting and investigative science. Initially, (1990-1992) the core of the project was the BOREAS - Executive (BEX), which has responsibility for overseeing the design and execution of the experiment, see Figure 2.3. BEX is made up of working level scientists drawn from the principal agencies involved in the project. Since the selection of investigators (late 1992), the science planning of BOREAS has been largely taken over by the BOREAS Operations Group (BOG) which consists of BEX members plus the Science Steering Group (SSG) composed of science team chairs. BOG reports to an agency oversight committee, the BOREAS Coordinating Committee (BCC), which is in place to ensure that the participating agencies' interests and missions are satisfied. The BCC is made up of agency program managers or equivalent people responsible for funding BOREAS. BEX works closely with the Science Steering Group (SSG) who represent the selected investigators, and is supported by staff scientists who coordinate or conduct much of the staff work. The project organization can thus be divided into the following components:

- o The BOREAS Coordinating Committee (BCC)
- o The BOREAS Executive (BEX)
- o The Science Teams, represented by the Science Steering Group (SSG)
- o Staff Support and BORIS

The roles of each of these are reviewed in the subsections below.

During FFCs and IFCs, an operational management structure is in place consisting of BEX, SSG and staff members. This structure is described in detail in Section 5.1.

2.3.1 The BOREAS Coordinating Committee (BCC)

The agencies providing core support for BOREAS are listed in Table 2.3.1; representatives of these agencies are at the program manager level or higher level. These people provided oversight for the early planning of BOREAS and conducted the proposal solicitation, peer review and investigation selections for BOREAS. The BCC has the responsibility of obtaining and allocating the resources for the project and may also direct BEX to take specific actions whenever a significant change in resource availability or other

BOREAS Management Structure

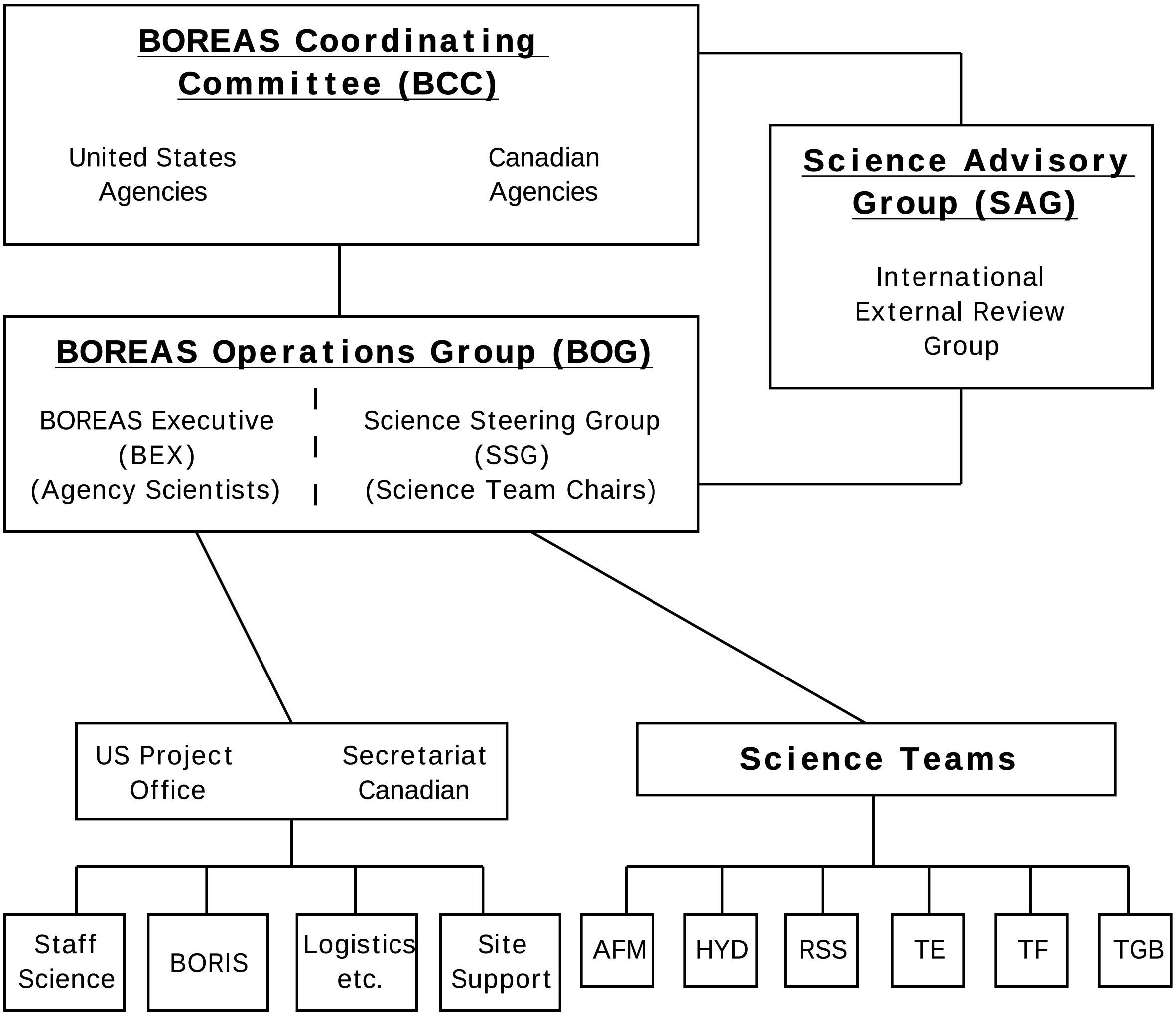


Figure 2.3 BOREAS Management Structure

operating factors could have a strategic impact on the execution of the project. The BCC will be assisted in its assessment of the progress of the project by the Science Advisory Group (SAG), formed in 1993. The SAG is to serve as an external review committee and will report to both the BCC and the BOG.

Additional agencies participating in BOREAS through sponsoring of Principal Investigators are listed in the lower part of Table 2.3.1.

Table 2.3.1

Core Support		
United States	**Canada**	**International**
NASA NOAA NSF EPA	Natural Resources Canada EC (AES, Parks Canada) NSERC Agriculture Canada National Research Council	
Additional Support		
United States	**Canada**	**International**
USGS USDA, Forest Service CRREL	Royal Society of Canada	NERC (UK) CNRM (France) CNES (France) SFI (Russia) Institute of Hydrology (UK)

2.3.2 <u>The BOREAS Executive (BEX)</u>

BEX is made up of working level scientists drawn from the principal agencies involved in the project. The major responsibilities of BEX are to:

- (i) Organize the science teams (selected investigators) and staff scientists, in conjunction with the SSG.
- (ii) Oversee the preparation and distribution of the experiment plan.
- (iii) Oversee the implementation of staff support activities (e.g. field infrastructure and BORIS).
- (iv) Oversee the execution of the field phase of the experiment, see Chapter 5.
- (v) Coordinate (with the SSG) the follow-up analyses, organize workshops, etc.

The BEX membership is shown in Table 2.3.2. BEX reports to BCC.

The BEX meets and works jointly with the Science Steering Group (SSG) to plan experiment operations and coordinate research priorities. BEX+SSG is known as BOG. BOG is the first point of contact for BOREAS participants for reporting their concerns and for settling of disagreements. The BOG will normally be chaired by a BEX member.

Table 2.3.2 BOREAS Executive (BEX) Membership

United States	Canada
D. Baldocchi (NOAA)	M. Apps (CFS)
F. G. Hall (NASA)	J. Cihlar (CCRS)
P.J. Sellers (NASA)	B. Goodison (AES)
	H. Margolis (NSERC CSP Project)

2.3.3 The Science Teams

The selected investigators were organized into six science teams during the December 1992 workshop, see Chapter 4 and summary in Table 2.3.3a.

Table 2.3.3a Summary of Science Teams and Principal Investigators

Airborne Flux and Meteorology (AFM)

Aircraft	Sounding/Networks	Models
AFM-1 Crawford	AFM-5 Atkinson	AFM-8 Betts
AFM-2 Kelly	AFM-6 Banta	AFM-9 Dickinson
AFM-3 Lenschow	AFM-7 Shewchuk	AFM-11 Mahrt
AFM-4 MacPherson/ Desjardins		AFM-12 Pielke
		AFM-13 Schuepp
		AFM-14 Sellers
		AFM-15 Verseghy

Tower Fluxes (TF)

Long-Term	IFCs	IFCs (cont.)
TF-1 Black	TF-4 Anderson	TF-8 Fitzjarrald
TF-2 den Hartog	TF-5 Baldocchi	TF-9 Jarvis
TF-3 Wofsy	TF-6 Bessemoulin	TF-10 Jelinski McCaughey
	TF-7 Desjardins	TF-11 Verma

Terrestrial Ecology (TE)

Soils, Forest Floor, Wetlands	Ecophysiology & Ground Carbon	Models
TE-1 Anderson	TE-2 Ryan	TE-13 Apps
	TE-4 Berry	TE-14 Bonan
	TE-5 Ehleringer/Flanagan	TE-15 Bukata
	TE-6 Gower	TE-16 Cihlar
	TE-7 Hogg	TE-17 Goward
	TE-8 Kharuk	TE-18 Hall
	TE-9 Margolis	TE-19 Harriss
	TE-10 Middleton	TE-20 Knox
	TE-11 Saugier	TE-21 Running
	TE-12 Walter-Shea	TE-22 Shugart
		TE-23 Rich

Snow/Hydrology (HYD)

Soil Moisture	Snow Processes, Remote Sensing	Hydrological Modeling
HYD-1 Cuenca	HYD-2 Chang	HYD-8 Band
	HYD-3 Davis	HYD-9 Soulis
	HYD-4 Goodison	
	HYD-5 Harding	
	HYD-6 Peck	

Trace Gas Biogeochemistry (TGB)

Methane	Isotopes, Pesticides	NMHCs
TGB-1 Crill	TGB-6 Wahlen	TGB-8 Monson
TGB-3 Moore	TGB-7 Waite	TGB-9 Niki
TGB-4 Roulet		TGB-10 Westburg
TGB-5 Zepp		TGB-12 Trumbore

Remote Sensing Science (RSS)

Optical	Microwave	Algorithms/Modeling
RSS-1 Deering	RSS-13 Gogenini	RSS-4 Curran
RSS-2 Irons	RSS-15 Ranson	RSS-5 Goel
RSS-3 Walthall	RSS-16 Saatchi	RSS-6 Williams
RSS-10 Holben	RSS-17 Way	RSS-7 Chen
RSS-11 Markham		RSS-8 Running
RSS-12 Wrigley		RSS-9 Strome
RSS-14 Smith		RSS-18 Green
		RSS-19 Miller
		RSS-20 Vanderbilt

The principal investigators belonging to each group are listed in Table 2.3.3a; team representatives - chairs, rapporteurs and BORIS Working Group (BWG) representatives - are listed in Table 2.3.3b.

Table 2.3.3b BOREAS Team Science Organization

Group	**Chair (SSG)**	**Rapporteur**	**BWG**
AFM	Kelly	Schuepp	MacPherson
TF	den Hartog	Fitzjarrald	Black
TE	Ryan	Gower	Knox
HYD	Lettenmaier	Davis	Soulis
TGB	Crill	Moore	Trumbore
RSS	Ranson	Miller	Deering

Each team is responsible for:

(i) Coordinating its science activities within the team
(ii) Coordinating team activities with other teams
(iii) Providing representatives to the SSG and the BORIS Working Group (BWG)
(iv) Working the list of staff science support and logistics items with appropriate staff members.

As far as possible, actions or intentions regarding the above items are to be documented in the Experiment Plan in Chapter 4.

2.3.4 <u>**Staff Science and Support**</u>

There are several activities that are essential to BOREAS that require continuous management. The BOREAS staff, which includes BEX and scientists and other employees of the agencies participating in BOREAS, is organized to take responsibility for this work. The activities include:

Site Management:	Coordination of activities at each site.
Site Logistics:	Installation of towers and power at the TF sites.

Environmental Impact Assessment:	Oversight of EIA studies and obtaining necessary permits.
Site Visits:	Organization of field visits and IFCs.
Laboratory Space:	Location and equipping of adequate lab space for each study area.
Meteorological Network:	The network of Automatic Meteorological Stations (AMS) and Upper Air (UA) stations.
Customs/Shipping:	Customs clearance, assistance in shipping to Canada.
Auxiliary Sites/Biometry:	Site selection and characterization
Calibration:	Calibration of radiometric instruments.
BOREAS Information System:	Collation, processing and distribution of BOREAS data.

The staff who manage these activities report to the BEX via the U.S. Project Office and the Canadian Secretariat, see Chapter 3.

2.4 Overview of Project Resources

Table 2.4 provides a condensed overview of the material resources available to the project for field data acquisition.

Table 2.4 Overview of Available Project Resources

Equipment	Measurements	Duration
a. Remote Sensing Aircraft (RSS, Staff)		
NASA DC-8	AIRSAR	FFC-T, IFCs
NASA ER-2	AVIRIS,MAS,AOCI	FFCs, IFCs
Piper Chieftain	CASI	FFCs, IFCs
NASA C-130	TMS, ASAS, MAS,POLDER	IFCs, FFC-T
NASA Helicopter	MMR, SE-590, POLDER, C-band scatt	IFCs
NOAA Aerocommander	gamma-ray	FFC-W, IFC-2,3
NRC Twin Otter	Microwave radiometers	FFC-W
CCRS DC-3	MEIS	IFC-2
CV-580	SAR	FFC-T, IFC-2
b. Flux Aircraft (AFM)		
NCAR Electra	τ, H, λE, CO_2, [t.g.]	IFCs
U. Wyoming King Air	τ, H, λE, CO_2	IFCs
NRC Twin Otter	τ, H, λE, CO_2, [t.g.]	IFCs
NOAA Long-EZ	τ, H, λE, CO_2	IFCs
c. Meteorological Networks (AFM)		
10 Automatic Weather Stations	(See 3.2.1)	1993-1996
Upper Air Network (augmented)	(See 3.2.2)	1993-1994
d. Towers (TF)		
2 Long Duration Towers	τ, H, λE, CO_2, [t.g.]	1993-1995
7 IFC Towers	τ, H, λE, CO_2	IFC-1 through 3
e. Chambers, porometers, etc. (TE, TGB)	CO_2 fluxes, t.g.	IFCs
f. Hydrology (HYD)		
Gaged Catchments (SSA, NSA)	Surface obs, rain radar	1993-1995
Snow Monitoring Network Soil Moisture	Surface obs. Neutron probe, TDR	FFC-W, FFC-T 1994
h. Remote Sensing (RSS, Staff)		
Radiometers	BRDF, optical properties	IFCs
Calibration Equipment	All surface/aircraft sensors	IFCs
i. Ground based remote sensing		
UHF Profiler	Profiles of horiz. wind, temperature, turbulence.	IFCs 1-3
Lidar	Profiles of horiz. wind, temperature, turbulence.	IFC 2
Radar	BL height and aerosol profiles.	IFC 2