PROCEDURES MANUAL

For

LARCH SAWFLY POPULATION DYNAMICS STUDIES

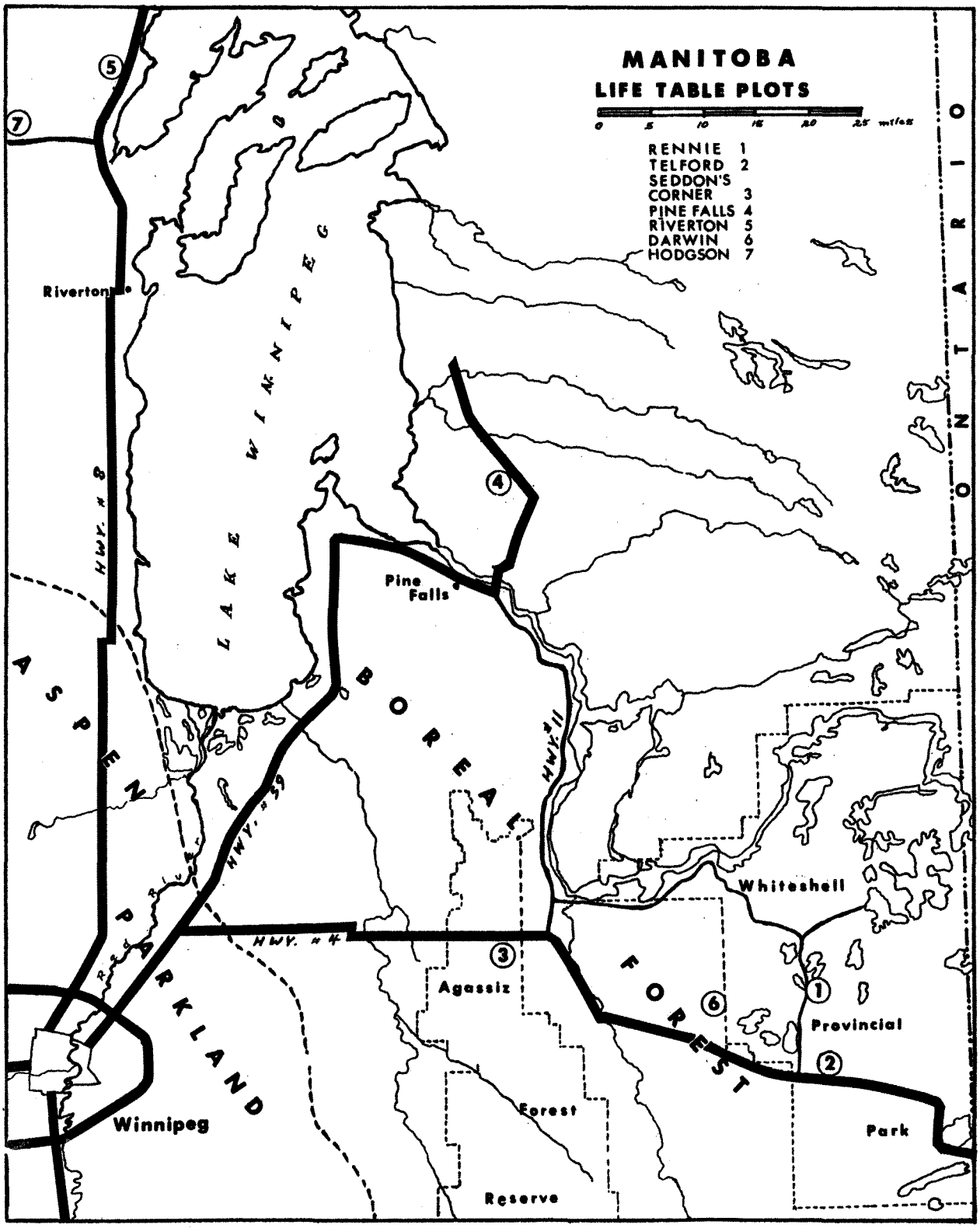
1966

by

J.A. Drouin, R. Smith, M. Pocatello

Forest Research Laboratory
Winnipeg, Manitoba
Internal Report 38

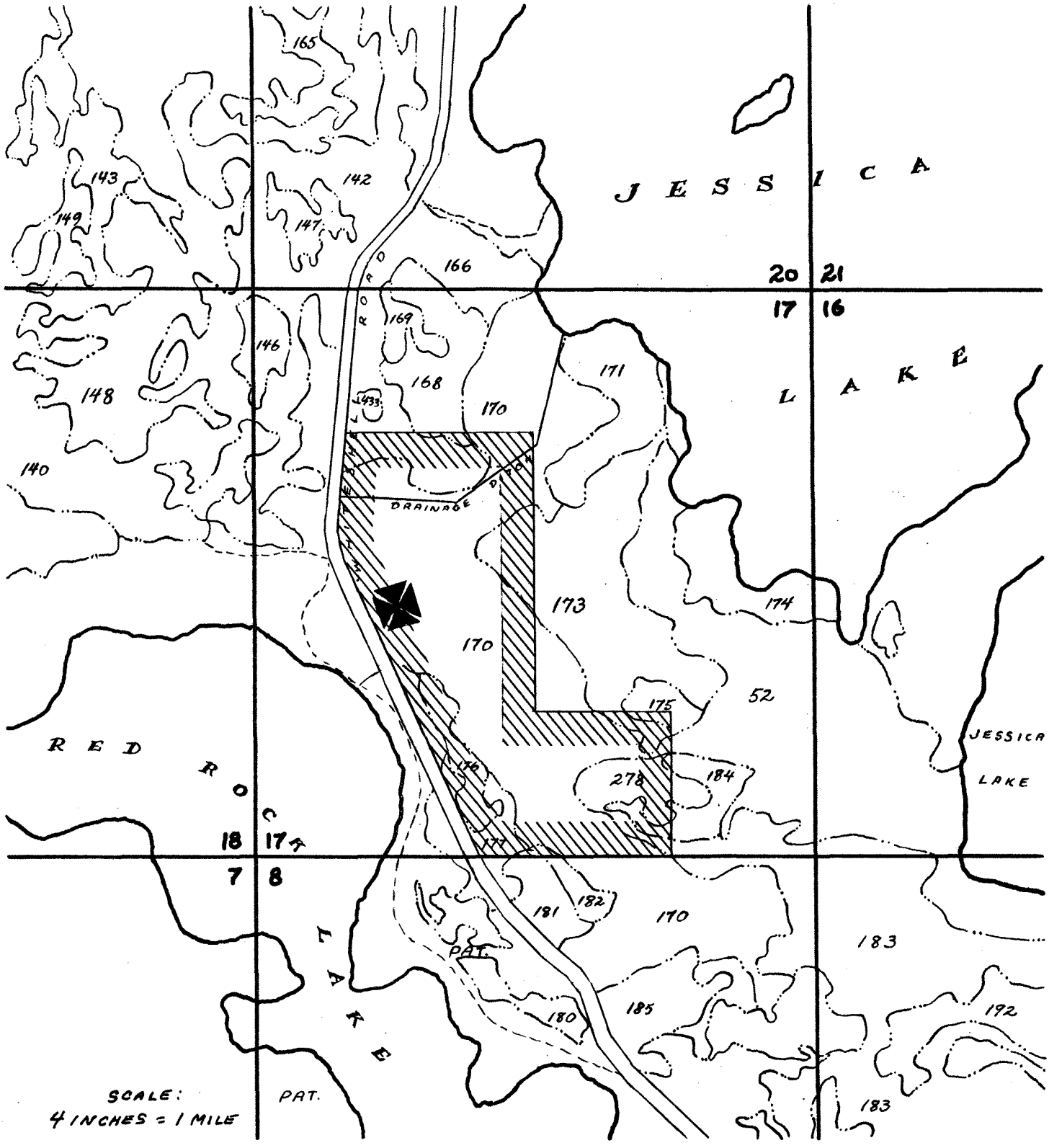
Department of Forestry & Rural Development
December 1966


MANITOBA
LIFE TABLE PLOTS
0 5 10 15 20 25 miles
RENNIE 1
TELFORD 2
SEDDON'S CORNER 3
PINE FALLS 4
RIVERTON 5
DARWIN 6
HODGSON 7
ONTARIO
Riverton
LAKE WINNIPEG
HWY. # 8
Pine Falls
HWY. #11
ASPEN PARKLAND
BOREAL FOREST
HWY. #59
Red River
HWY. #4
Agassiz
Provincial Forest Reserve
Whiteshell Provincial Park
Winnipeg

LARCH SAWFLY LIFE TABLE RESEARCH AREA - PLOT #1
Forest Entomology Laboratory, Winnipeg, Man.

Location - Rennie, Whitesnell Forest District
Area requested to be reserved - area lying east of Whiteshell Road in L.S. 2, 3, 5, 6, 11 & 12; Sec. 17, Tp. 12, Rge. 15 E.P.M.

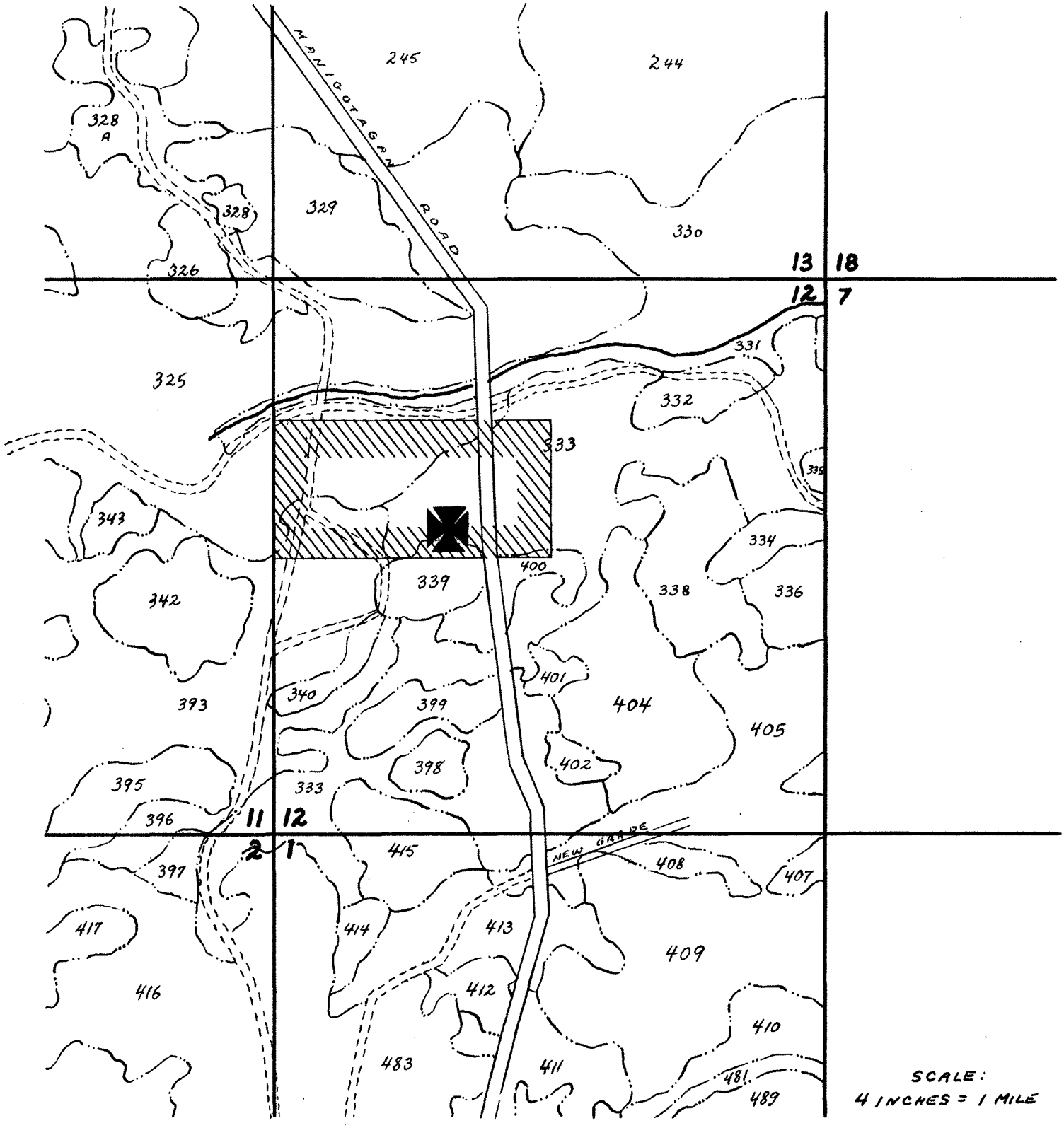
Plot established - 1955



LARCH SAWFLY LIFE TABLE RESEARCH AREA - PLOT #4
Forest Entomology Laboratory, Winnipeg, Man.

Location - Pine Falls, Eastern Forest District
Area requested to be reserved - L.S. 11 & 12, Sec. 12, Tp. 20, Rge. 10 E.P.M.

Plot established - 1961

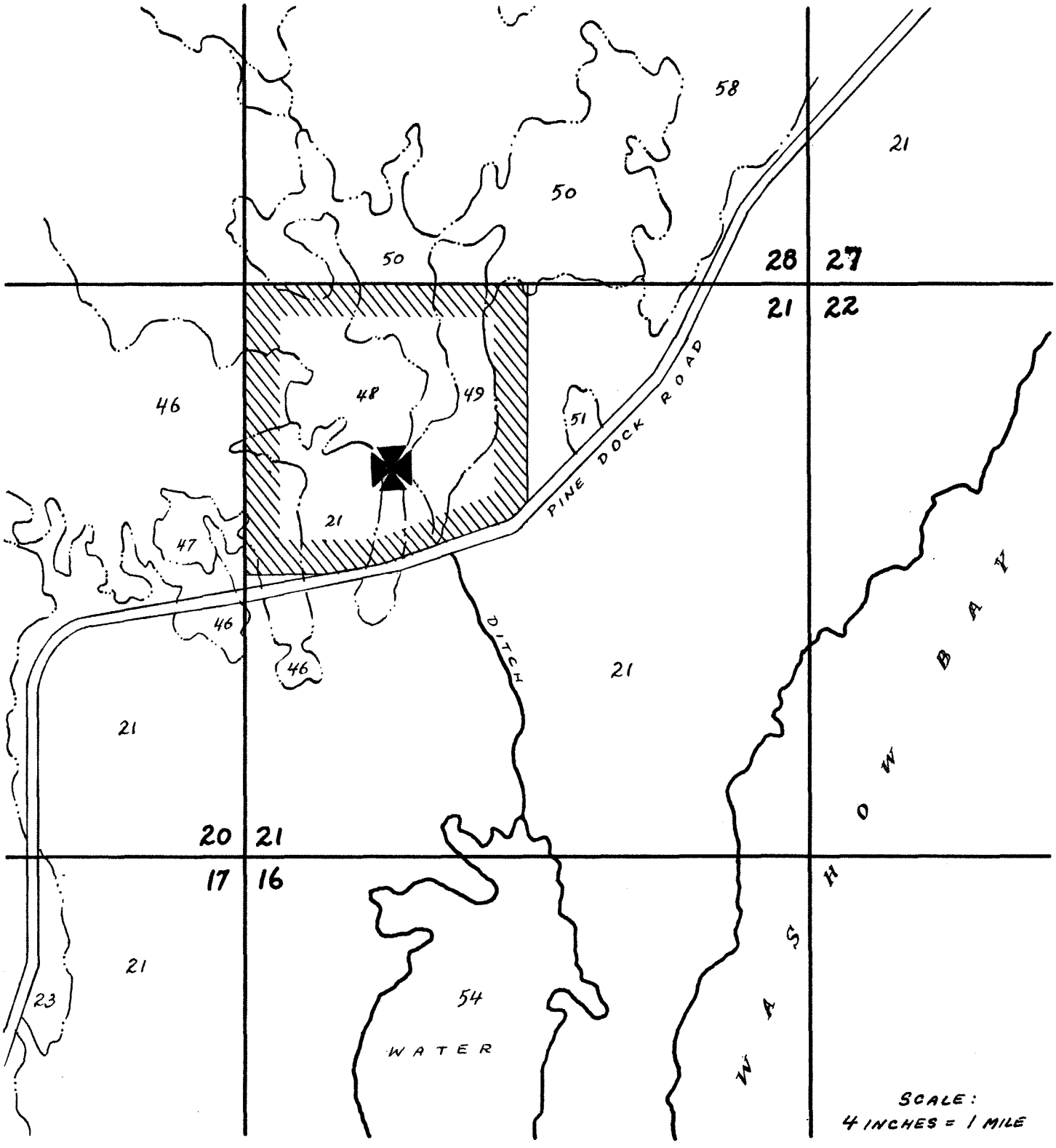


SCALE:
4 INCHES = 1 MILE

LARCH SAWFLY LIFE TABLE RESEARCH AREA - PLOT #5
Forest Entomology Laboratory, Winnipeg, Man.

Location - Riverton, Central Forest District
Area requested to be reserved - area lying north of Pine Dock Road in L.S. 11, 12, 13 & 14, Sec. 21, Tp. 26, Rge. 4 E.P.M.

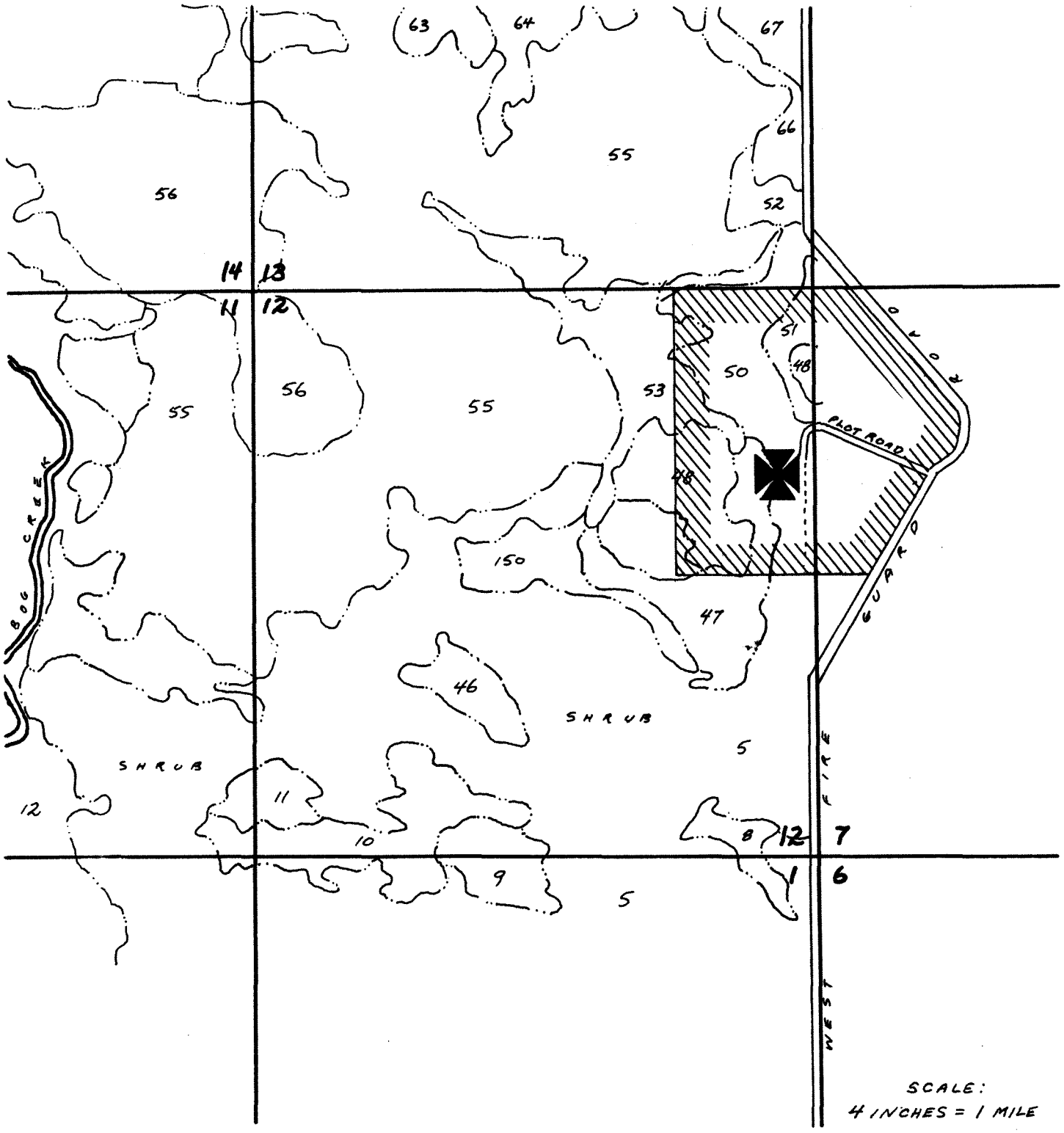
Plot established - 1962



LARCH SAWFLY LIFE TABLE RESEARCH AREA - PLOT #6
Forest Entomology Laboratory, Winnipeg, Man.

Location - Darwin, Eastern Forest District
Area requested to be reserved - L.S. 9 & 16, Sec. 12, Tp. 12, Rge. 12 E.P.M. and area lying west of fire guard road in L.S. 12 & 13, Sec. 7, Tp. 12, Rge. 13 E.P.M.

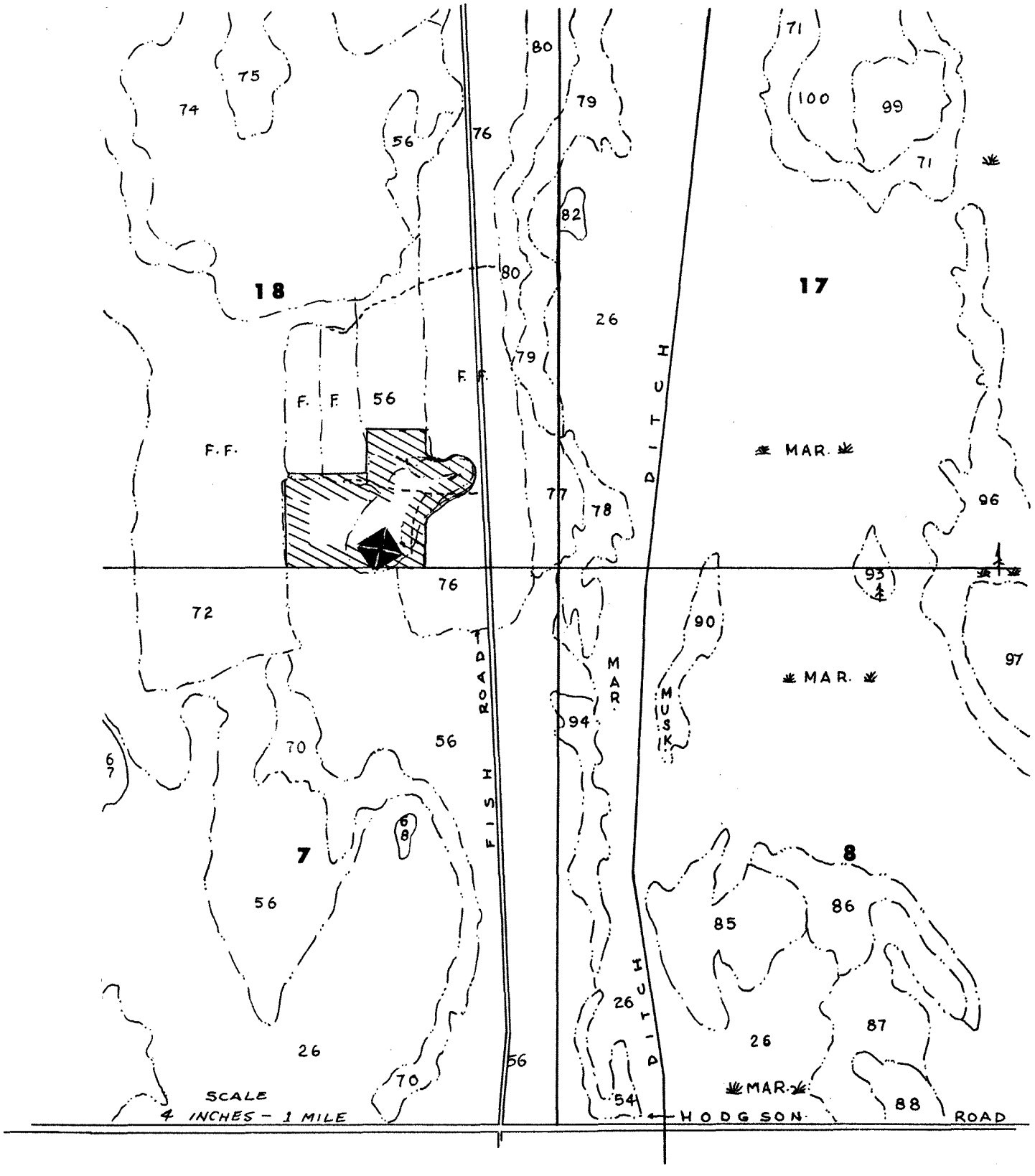
Plot established - 1963

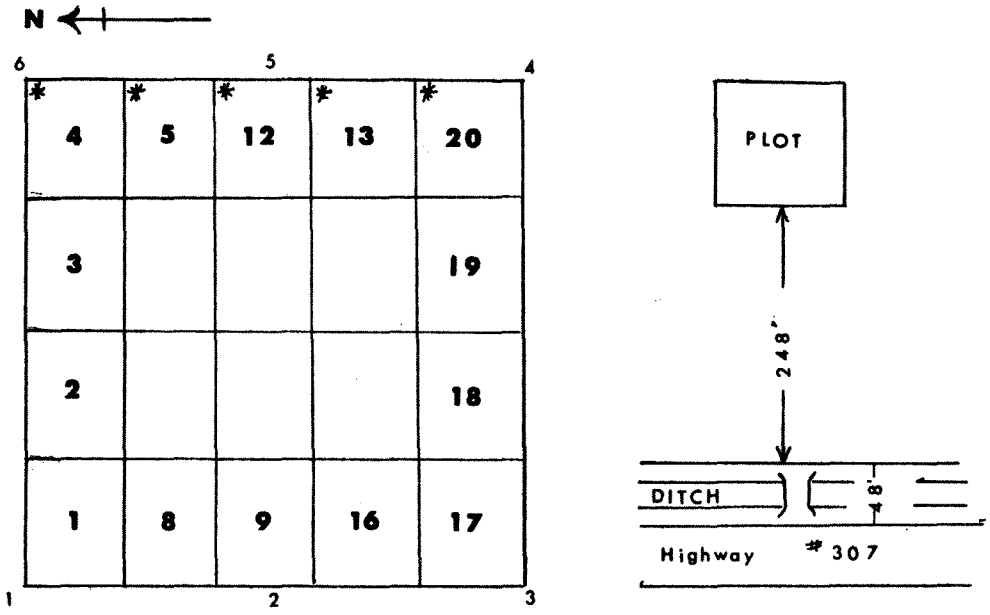


SCALE:
4 INCHES = 1 MILE

LARCH SAWFLY POPULATION DYNAMICS STUDY AREA - PLOT #7
Dept. of Forestry, Winnipeg, Man.

Location - Riverton, Central Forest District
Area requested to be reserved - area one and one tenth mile north along Fish road from junction of Hodgson road and Fish road in L.S. 2, Sec. 18, Twp. 26, Rge. 2, E.P.M.



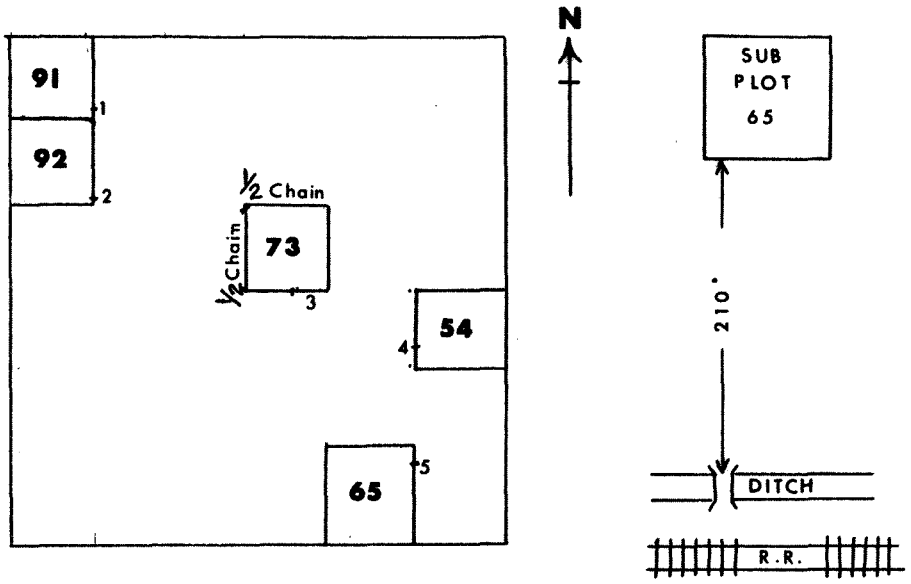


1-6 : Water level pipes

*Sub plots not randomized - eliminated 1959 - retained for mortality

RENNIE I

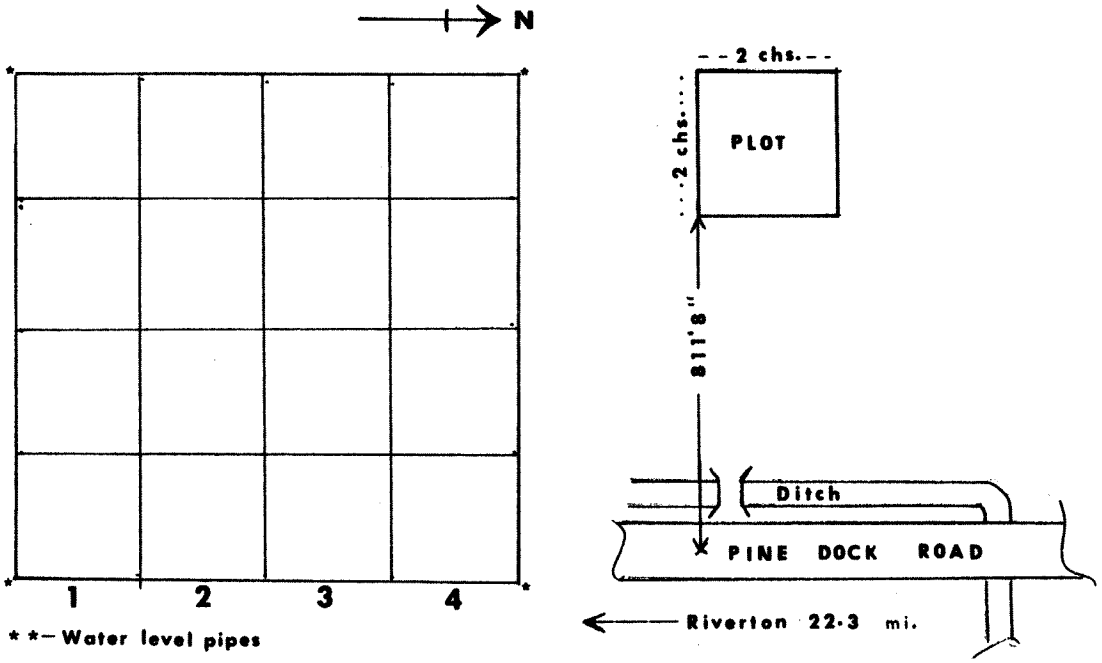
Grid - 6-015-256



1-5 = Water level pipes

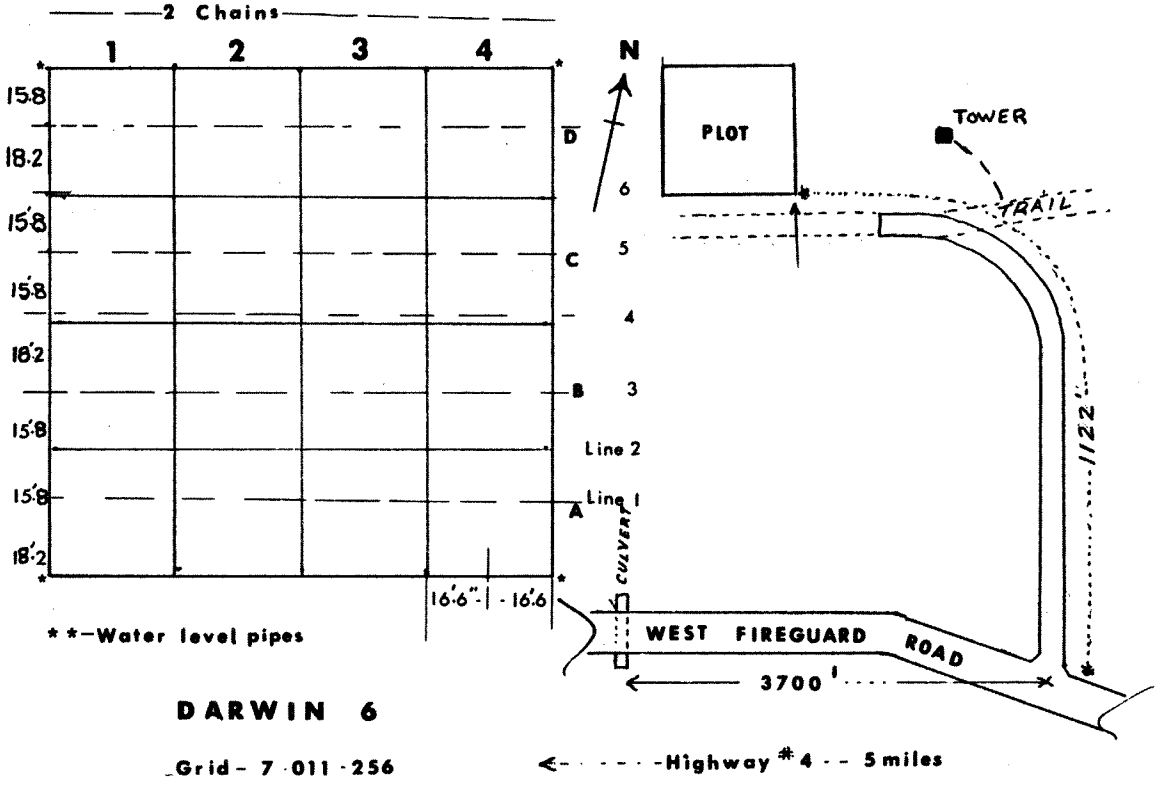
TELFORD 2

Grid - 7-016-253



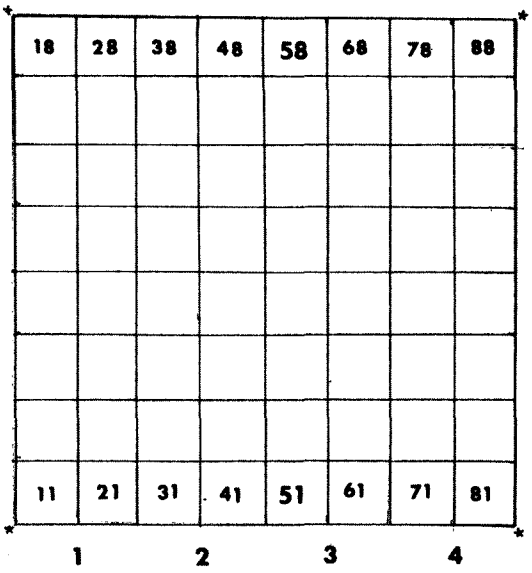
RIVERTON 5

Grid – 7-087-278

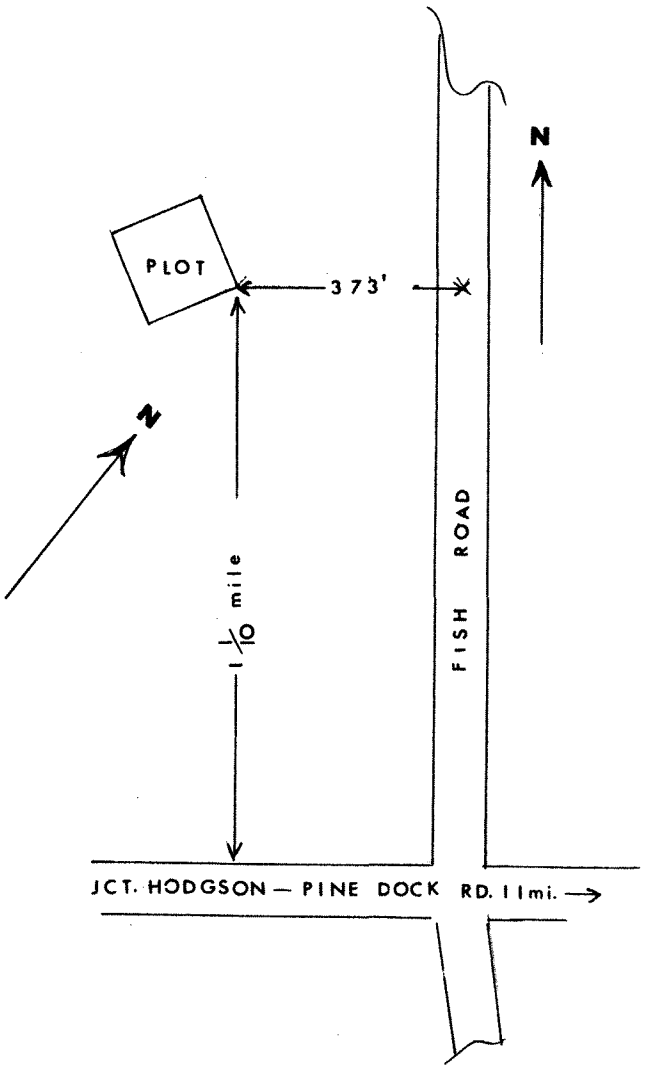


DARWIN 6

Grid – 7·011·256



** Water level pipes



HODGSON 7

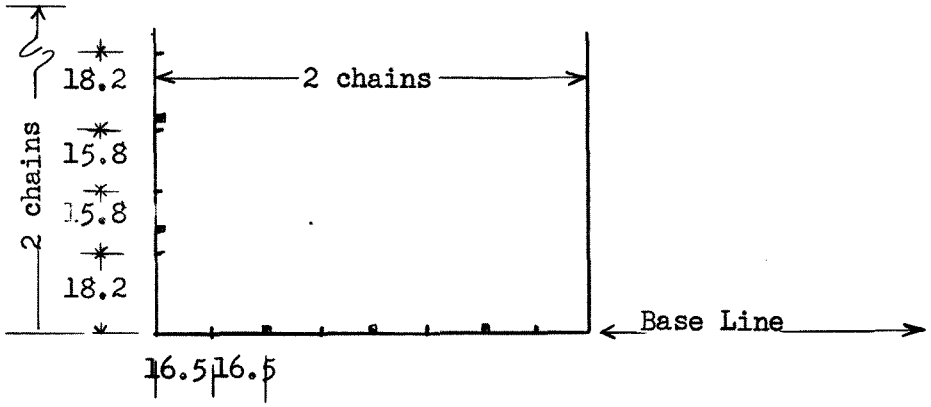
LS-2, Sec. 18, Twp. 26, Rge. 2, EPM

Grid - 7 - 084 - 277

METHOD OF ESTABLISHING PLOTS

Plot Layout:

1. Select site 2 x 2 chains in size. Mark each corner of the plot with a 4 x 4 cedar post painted yellow. Clear all the dead branches within the plot and approximately 3 feet around the perimeter of the plot up to 7 feet in height for ease in moving around. Starting at the base line drive in 2" x 2" x 3' stakes every 16.5 feet alongside the base line. Running vertically from the base line drive in stakes at 15'8", 18'2", 15'8", 15'8", 18'2", etc. according to plot map.



2. Tally all living trees more than 4 feet tall (1 inch d.b.h. and over). Blaze and mark all dead trees on the plot at time of tally. Nail tree tags at breast height, drive nails just enough to hold tags firmly with the head of the nail slightly lower than the point, and pull tag towards head of nail. If possible use copper clout nails and for ease of locating, tag all trees on same side. Include in tally book tree species of each tree tagged, D.B.H. and crown class using the following nomenclature:

D - dominant, overtopping rest of stand.

CD - co-dominant, beneath dominant but receiving sunlight on top and sides of crown.

S - supressed, beneath all other living classes; receiving little or no direct sunlight.

Larval drop positions

Once the stakes marking all lines are established, 100 permanent 2-foot-square larval drop positions are selected from a possible 8712 positions for a 4/10 of an acre plot using a random numbers table. These positions are located in the plots with a special jig which indicates the center of each selected position using the 2" x 2" stakes as reference points. Each larval drop funnel is hexagon shaped. In each

of the selected positions three 4-foot-long permanent aluminum stakes are driven in. Each stake is pre-drilled to accommodate hooks (F5X single loop hooks) for larval drop funnels with the sample position number stamped and painted on.

Emergence cage positions

Each of the larval drop positions has a possible 6 positions for emergence cages around its periphery. Two positions are located randomly leaving one position between them empty at all times. The two selected positions are marked by two 3-foot aluminum stakes with numbers corresponding to the larval drop position. The inside top 3 inches of the stakes are painted red for positions used in odd years and black for the even years.

Installation of duck boards

Prior to 1964 all plots were equipped with a network of slab duck boards laid on the main access trails to promote access and prevent trampling of positions or generally disturbing the ecological balance of the plot floor. These have deteriorated and are being replaced with a 2" x 12" rough lumber system of duck boards. With this new network of access walks to emergence, larval and oil drop cages, disturbance is negligible. The planks varying in length from 8, 10, 14 and 16 feet are laid on the perimeter of the plot, with side access walks to the oil drop position. Two main walks through the center of the plot reach all funnels and cage positions. Dependent on topography of the plot the planks are supported by foot high piers resting on 18 inch to 2 foot pads, the whole spiked together for rigidity. During sampling procedures for branch, foliage or otherwise where use of duck boards is impossible, care should be exercised by the operators to avoid trampling on the staked positions.

Installation of water level pipes

After a plot has been established, four, six-foot long $1\frac{1}{4}$ inch galvanized pipes are driven into the ground until twelve inches remain above ground level. These pipes are closed at one end and have 5/16" holes drilled at intervals along the pipe, allowing water to flow into the pipe.

Five of the present sample plots have (4) pipes while Rennie and Telford have six (6) and five (5) respectively. All pipes are identified by compass direction (NE, NW, SE, SW) or numbered one to six. Red, six-foot aluminum angle stakes, with corresponding numbers stamped in the metal, have been located beside the pipes for ease in locating these during the winter months.

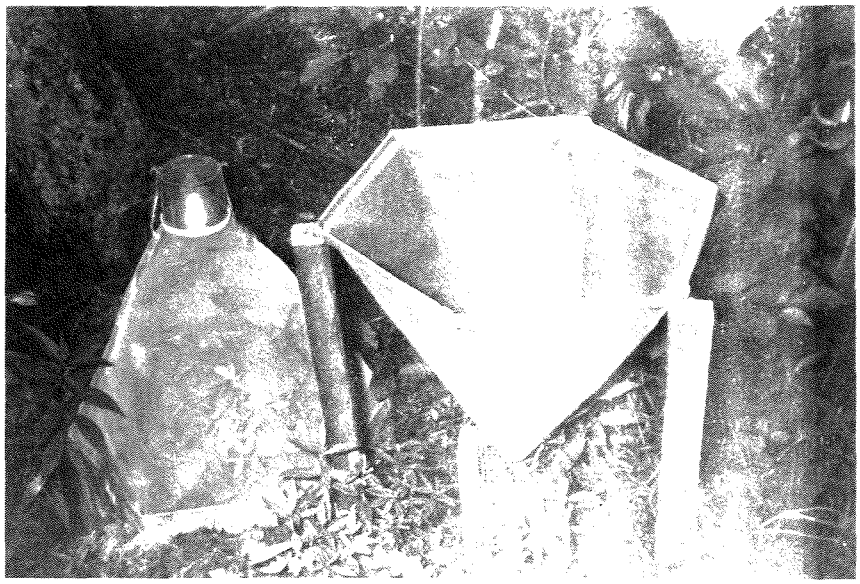


Photo C. Burdall

Emergence trap and larval drop funnel.

Photo C. Burdall

Oil drop funnel.

Installation of stakes for measuring microtopography

Topographical measurements are taken at all life table plots every fourth year. These measurements are based on an artificial datum and given an accurate, representative picture of the changing surface features of the plots.

Establishing positions

Shave the tops of four 2 x 2, three-foot stakes to insure a proper fit in the metal shoe of the measuring jig. Beginning at the left-hand corner of the base line (Line 1.), drive in the first stake. The remaining stakes are positioned with the aid of a six-foot right-angled jig to assure a perfect six-foot square. The position of the fourth stake is determined by moving the jig to either the second or third stake. Avoid driving the stakes firmly, as they must be levelled with the artificial datum. Longer stakes are advisable in low marshy areas.

Proceeding right along the base line, establish 25 six-foot grids every 33 feet within the plot. Lay out five lines of five grids apiece.

Setting up the water fount (artificial datum)

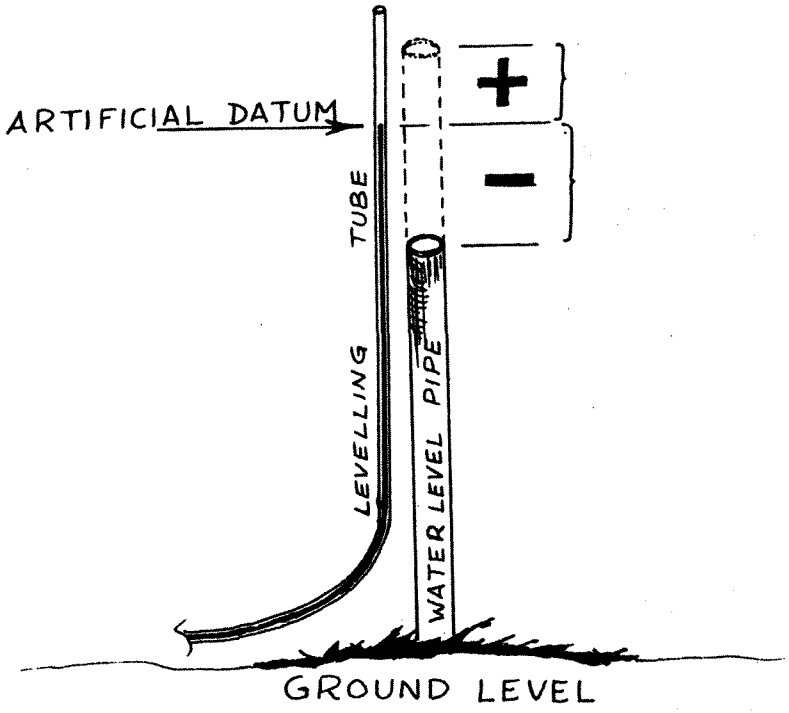
Determine the centre of the plot and drive in four 2 x 2 stakes to a level approximately one foot above the highest root-crown or hummock. To the top of these stakes, nail a 3/4" plywood platform previously cut with a "V" notch on one edge. The notch allows the copper tube of the water fount to overhang the platform thus avoiding unnecessary tipping of the unit. Fit the plastic tubing snugly over the copper tube in the fount base. Fill the gallon jar with water, adding two ounces of red ink to provide colour. Fit the fount base over the jar lip and invert entire unit, placing it on platform.

Prior to levelling stakes, carefully check plastic tubing for trapped air bubbles. Air bubbles are removed from the plastic tubing by holding the fount unit shoulder high which accelerates the bubble flow out the open end of the tubing. Keep line clamped firmly shut between levelling operations.

Levelling stakes

Carefully lay the tubing through the plot to grid one along ground level. Hold tubing beside, and two or three inches above stake level. Wait until the water in tube stabilizes with artificial datum of fount, then drive stake down until top is level with datum. All four stakes are done in this manner. Avoid stepping within six-foot grid.

When levelling stakes at grids 1, 5, 21 and 25 (the corner grids), levels must also be taken from the tops of the water level pipes in each of these corners. The measurements should be expressed in positive (+) inches if the top of the water level pipe is above the artificial datum and negative (-) inches if the pipe is below the datum. Draw a sketch in the record book to clarify this point.



Defoliation records, growth and survival

In order to evaluate the effect of the larch sawfly on the host, the influence of defoliation on radial and terminal growth, and possible successional changes in stand composition resulting from these attacks, records from the six life table plots are taken annually. Records are maintained for the individual trees for defoliation, shoot and foliage length, growth and/or deterioration and mortality, and the influx of secondary insects.

Methods

1. Record plot, location, tree number, shoot production, shoot length, needle length and adventitious shoots above and below crown. In second half of form W62A enter date and defoliation estimates only, dead branch description and cone production.

2. All data to be recorded at completion of larval feeding.

3. Remarks to include any pertinent information on water levels and secondary insects in the immediate area.

4. To establish estimates of production or length, the class limits are as follows:

Shoot production:	light = 0.5 per branch medium = 6-25 per branch heavy = 25 + per branch
Shoot length:	short = less than 35 mm. medium = 36-50 mm. long = 50 + mm.
Needle length:	short = less than 10 mm. medium = 11-20 mm. long = 20 + mm.
Cone production:	light = 0-4 per branch medium = 5-15 cones per branch heavy = 15 + cones per branch

5. Defoliation for each tree is later calculated using the weighing factors below and entered in the laboratory record books (blue books).

Upper .17 Mid .47 Lower .36

In levelling, cages on uneven ground are levelled with legs and plates. First attach legs with self-tapping 3/8 x 4 screws until desired height and stability is attained. Apply plating by sliding these in at an angle with retaining bands to the outside. Slide first plate down until in firm contact with ground, allowing sufficient overlap with each succeeding plate until no gaps are left. Finally tighten screws holding legs and check for cracks. If water levels are low enough at this time, uncontaminated moss should be tamped around the base of cages into cracks or crevices which might permit emerging insects to escape. Mossing should be completed as soon as water levels recede. Sponges are then slipped over the apex and the plastic traps are clipped on.

Servicing - Field

Emergence cages are serviced every second week. Undo spring clips, remove color-coded numbered plastic trap, cap with lid and replace in carrying basket in sequence. Replace immediately with like-numbered trap with the opposite color-code assuring tight fit over sponge, then clip. As the season progresses cut any grasses or shrubs growing inside the cages which may clog hole at apex.

At the field laboratory the traps for respective plots are handled as follows: remove plastic retainer ring with trap upright and slip out metal cone. Invert trap, and using soft brush for assistance spill insect contents onto clean sheet of paper. Check for larch sawfly adults, if any, remove and record plot, number and collection date. The remaining contents are "poured" into the pillbox between the dacron fold. The box is labelled with plot, cage number and collection date. (i.e. R-52-7/7/64). Stack by collection date in container used for this purpose.

Servicing - Laboratory

In sequence, one collection date of pillboxes are layered, slightly opened and placed in a relaxing jar with expanded metal lath separators. After 10 to 14 days the contents are ready for examination, pinning and recording. Add small amount of phenol to water to retard molds. Medium and large specimens are pinned through the right wing cover. Small specimens are mounted on points with the bent tip of the point glued with Cilux household cement, mixed with 1/3 amyl acetate, to the right side of the insect. Homoptera and Diptera should be pinned with the pin slightly to the right of the midline of the prothorax. Once pinned or pointed all insect specimens should be labelled - showing plot and date collected. The emergence cage number is printed on the back left hand corner of the label (i.e. R-40). Labels are pinned through their centre using a pinning block (second step) for proper height.

A list of insect specimens to be retained, recorded or discarded follows. This listing may vary from year to year depending on studies underway and the emphasis on any particular species. Characters of value in identifying Holocremnus are also presented.

RETAIN and/or RECORD	DISCARD
Coleoptera, all	Collembola (Springtails)
Record and discard water, fungus, rove, net-wing, firefly soldier, carrion, flower, skin, sap, click, fire, and snout beetles	Plecoptera (Stoneflies)
	Ephemeroptera (Mayflies)
	Odonata (Dragon & Damsel flies)
Hemiptera, all	Orthoptera (Grasshoppers)
Discard water striders, lace bugs, toad, and water bugs	Dermaptera (Earwigs)
Homoptera	Thysanoptera (Thrips)
Discard lantern flies, tree, leaf and frog hoppers, aphids	Trichoptera (Caddisflies)
Neuroptera	Lepidoptera
Discard fishflies, ant lions Retain all lacewings	Siphonaptera
Diptera	
Retain all tachinids, Syrphids, Bombylids - discard remainder. (midges, flies, gnats)	
Hymenoptera	
Retain all sawflies, Ants Ichneumonids, Bombids, Vespids	

Characters for the recognition of Holocremnus sp. near nematorum Tschek

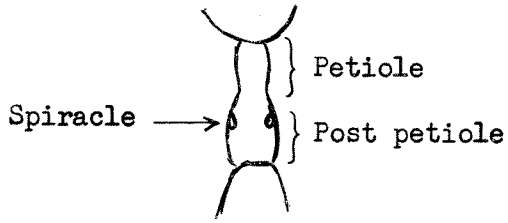
Size Length 5-7 mm.

General color - Head, thorax and abdomen black, sometimes with reddish markings on the sides of abdominal segments 2-4.

Legs as follows: front and middle coxae, front and middle trochanters and apex of hind trochanter, yellowish - sometimes with the bases of coxae blackish, hind coxa black, femora and tibiae reddish.

Antenna - scape with a yellow spot on lower surface.

Structure - First segment of abdomen slender (petiolate) on basal 0.5 to 0.66, beyond dilating to form a broader post-petiole, the spiracles located near the base of the post-petiole (see sketch).

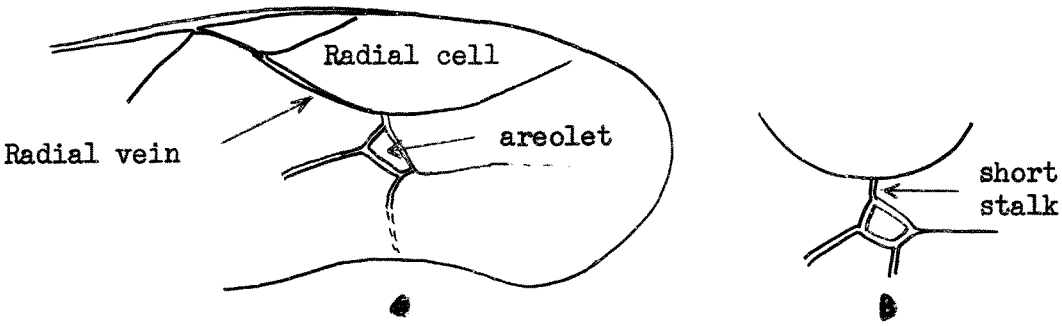


Abdomen beyond the first segment moderately compressed; in female with ovipositor and sheath concealed or not longer than depth of abdomen at apex.

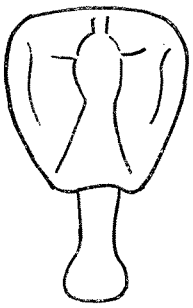
Structure - Face and clypeus not separated by a distinct groove or furrow; both dull and rather evenly, finely, granularly sculptured.

Thorax dullish, and in most regions finely punctate, the punctures often obscured by fine granular sculpture.

Front wing (see sketch a) with a small 4-sided, somewhat oblique, closed cell behind the radial cell. This cell (termed the areolet) with its two anterior sides converging in front to join the radial vein at their basal angle or appended from the radial cell by a short stalk (sketch b).



Propodeum finely rugose and with distinct oblique and longitudinal carinae arranged much as in sketch.



Egg Populations

Purpose

Random sampling techniques are employed for assessing certain aspects of the population dynamics. Randomization of trees is used for assessing egg populations in each of the six sample plots. Two systems are employed because all the plots do not contain the same type of stand.

METHODS

Simple random sampling

The four plots in which this technique is employed are as follows: Rennie 1., Seddon's Corner 3., Riverton 5., and Darwin 6. The number of trees selected for sampling is forty trees per plot for Rennie, Seddon's Corner and Riverton. In Darwin only thirty trees are used because of the low number of stems per acre. This is due to the mature nature of the stand. In randomizing proceed as follows:

1) Check the "blue" books for the numbering sequence of tamarack trees used in each plot.

2) Using the last three digits of each column of the tables draw the random numbers within the numbering sequence.

3) Check these numbers against the "egg sampling" section of the "blue" book to be sure the trees have not been sampled in the preceeding two years or are dead.

4) Continue this process until the required number of trees have been drawn plus four or five "spare" trees.

Stratified random sampling

The stratified sampling technique is used in Telford 2., Pine Falls 4., and Hodgson 7. sample plots. In the Telford plot the trees are divided into four classes: < 5 feet, 6-10 feet, 11-15 feet and 16 > feet. The total number of trees in each class is recorded (N) as well as the number of trees to be sampled (n). In the Telford plot the four totals are: < 5 feet - N=61, n=13; 6-10 feet - N=96, n=22; 11-15 feet - N=16, n=4; and 16 > feet - N=3, n=1. The total number of trees in the plot is 176. In the Pine Falls plot there are six classes: < 5 feet, 6-10 feet, 11-15 feet, 16-20 feet and 20 > feet. The totals of the classes are as follows: N=69, n=5; N=133, n=9; N=128, n=9; N=144, n=10; N=67, n=5; N=32, n=2. The total number of trees in the plot is 570. The classes

for the Hodgson plot have not been established. In the stratified random sampling, trees may die each year and it becomes necessary to recalculate the number of sampling trees from each strata. Two spare trees should be selected per strata.

The total height of a tree is taken by measuring from the bottom of the tree to the base of the leader with a set of aluminum poles. The poles are in standard six foot lengths which join together. The random trees are measured for total height. Where a dead tree is encountered an appropriate spare should be selected. The dead trees should be marked "dead" in the field record book. If no dead trees are encountered, the "spares" may be disregarded. The crown depth is obtained by subtracting the height from the ground to the lowest living branch (living branch= any branch over 12" in length) from the tree height. e.g. Height=23 feet, Lowest Branch=5 feet, Crown Depth=23 - 5 = 18 feet. Later at the field station the crown is then divided into three equal crowns; lower, middle and upper. To find the ranges of the three crown levels subtract two feet off the crown depth. One foot is inserted between the lower and middle crown, the other, between the middle and upper crown to prevent the overlapping of the crown limits. Then divide the result by three, the crown levels. The quotient is 5 and a remainder of 1. To the lowest branch figure add five, 5 + 5 = 10. Start the middle crown level one digit higher, 11 + 6 = 17. Six is added here to take care of the remainder of one. (Where the remainder is two, one is added to both the lower and upper crown levels.) Add one digit to start the upper crown level, 18 + 5 = 23. The final figure should equal the total height of the tree. Some problems will occur in Telford and Pine Falls where the smaller trees are drawn for sampling, (a crown depth of less than eight feet). In this case the crown should not be divided but the whole tree sampled if possible.

Once the crown boundaries have been established, the trees chosen are randomized for branch height and cardinal direction in each level of the crown. Two heights are selected per crown. This is done by selecting the numbers from the last two columns of the random number tables and between the crown boundaries. The cardinal points are selected using North (N) = 1 or 5, South (S) = 2 or 6, East (E) = 3 or 7, and West (W) = 4 or 8. For this purpose only the last figure of the column should be used. The two branches selected should not come from the same height and same direction. When this occurs, a new direction should be drawn from the random tables.

Every three years the two sampling methods described above are used for foliage sampling. The method should be followed exactly but a new set of trees should be drawn for each plot to prevent mechanical de-foliation of the tagged trees. This type of sampling is not carried out until the foliage has ceased its growth (mid-June to early July).

Sampling egg populations in field

This method of sampling is used to make population estimates in the egg stage. The eggs are inserted in the shoots of the current season's growth usually causing the shoot to curl as the season progresses. These curled tips bear the oviposition scars. Eggs can be counted accurately using a binocular microscope at 10X magnification.

Method

The 40 tagged trees to be sampled are selected at random. The height of each tree is measured accurately with the aluminum poles used in pruning. These are taped or painted with a stripe at 1 foot intervals. The 6-foot lengths are joined together by the pole operator to the height of the tagged tree selected. An assistant standing back some distance from the tree being measured can direct the pole operator until the poles reach the top of the tree. The tree height and crown depth to the lowest living branch 12 inches in length or over is then recorded. The crown depth is then divided into upper, mid and lower thirds. Before sampling, random numbers are drawn to determine height and the cardinal compass point from which each of two branches is to be sampled in each third of the crown. The pole operator should select the branch nearest the randomly selected sampling location. An assistant with binoculars is necessary in trees over 30 feet in height to direct the pruner head jaws gently to the selected branch position. Once engaged in the pruners the branch should be cut and lowered gently to the ground avoiding any breakage or loss of shoots. The number of shoots on each individual branch is then counted and recorded. Curled shoots are bagged and the plot, tree, position and shoot numbers indicated on the bag. Branch counts are carried out only on those crown portions having curled shoots. The crown levels are identified in the field by tying brightly colored plastic ribbon to the poles at appropriate heights. The total number of branches in each third is counted with the aid of binoculars and recorded.

Laboratory procedure - field

The bagged shoots should be refrigerated as soon as possible and left in this condition until egg counts are started. Use a binocular microscope at 10X magnification. 1. Count the number of oviposition slits on each curled shoot. 2. Enter total egg slits in record book with tree number, direction, and branch height.

The resulting counts are used in calculating the total eggs per branch, crown level and per tree to give an estimate of egg population per plot and per acre.

Egg and Larval Mortality

Shoots containing eggs

Shoots containing eggs are collected weekly during the adult oviposition period by the servicing crews at each plot. These provide a basis for estimating the annual mortality of egg populations in the life table plots.

Handling in the field

As oviposition becomes apparent, mass collections of shoot containing eggs are collected around the periphery of the plots. Clip or break the shoot containing eggs, allowing, where possible, 2 to 4 inches of stem. Avoid touching the egg shoots, and carefully strip the foliage leaving only 8 fascicles below the shoot before placing the egg shoot in the rearing tubes. Less foliage does not provide adequate food for the emerging larvae, more causes excessive humidity in the tubes. Record plot, date of collection and information relating to predators, if any, or the predator sampling branch level code where applicable. All rearing tubes containing egg shoots from invertebrate predator sampling must be identified with a red label. If larvae are emerging at time of collection indicate as emerging on tube label. Keep tubes and shoots away from sorting tables, or direct sunlight. Always keep racks stored in cool, moist locations.

Transportation to field laboratory

All precautions should be exercised when transporting egg rearing tubes to prevent desiccation or extreme fluctuations in temperatures. A layer of very wet moss along the bottom of the cooler before stocking the egg racks will assure adequate moisture providing the basal ends of the shoots are in contact with the saturated moss.

If egg shoot collections are not recorded and racked in the rearing tubes but transported in the styrofoam cooler, the following precautions should be taken:

1. Remove the ice pack well before collecting and allow temperature in the cooler to moderate.

2. Wrap the basal ends of the egg shoots with saturated moss and store upright in the plastic cooler compartment.

Handling in field laboratory

Immediately on arrival at the field laboratory handling procedures are as follows:

1. Remove egg shoots from coolers, rack in vials, identify and place racks in watering trays according to plot and date of collection. Insure that basal ends of every shoot is in water. Particular care is needed in this respect for shoots located at the end of the racks.

2. Examine racks for hatched eggs each morning, remove hatched eggs to a separate tray for each day.

3. Count eggs and larvae, recording date of collection, date of hatch, number of eggs, larvae and other information as to predators and crown code number the day after (a 24 hour delay is a necessity) eggs have hatched, keeping plots separate. Place larvae in rearing.

4. Always keep a supply of clean egg vials for the weeks use.

Shoots associated with larvae (Colony collections)

The colonies are collected weekly by the servicing crews and preserved in 70% alcohol. The data obtained is used in calculating survival in all instars.

Method of collecting in the field

Colonies and related shoots are collected in the vicinity of each life table plot.

1. In the early stages avoid preserving shoots with only partially emerged larvae. These should be classed as an egg shoot and treated accordingly.

2. After the 3rd instar, colonies tend to wander. When collecting these, make sure the colonies are associated with the curled shoot, otherwise ignore. If the colony is collected from invertebrate predator branch samples be sure to add a blue label in the collection vial as well as the standard collection label with all pertinent data and branch designation.

3. If predators are observed near early instar clusters these should be collected along with the colony and indicated on the collection label.

4. The colonies should be handled with care in the later instars (IV & V) since larvae drop readily when alarmed.

5. All collections must have a collection label number with proper plot designation, date collected and branch designation*.

Examination and recording of data

These collections are sorted as to plot and collection date at the field laboratory and transcribed to data sheets as follows:

1. Organize collections in sequence and by instars.

2. Record colony collection data on 80 column sheet (form A-332) following instruction on code card 07. Stamp in plot, year, write in type of collection (oil, colony etc.) and page number in the top right hand side of data sheet for identification.

Colony Collections - Pine Falls-Riverton

Handling procedures at both these plots are similar to the other plots except for some changes necessary to obtain all available data from an established parasite, Holocremnus sp. nr. nematorum Tschek.

The handling methods are described under "Oil drops - Pine Falls and Riverton", with the measurement tables for head capsule widths for normal and parasitized larvae.

Abundance of Invertebrate Predators and Associated Prey

This sampling method provides a means of assessing invertebrate predators and associated populations on the host tree at each life table plot.

Collecting samples in field

The sampling method is based on 20 branches (7 upper, 7 mid, 6 lower) taken from 20 trees selected at random in the vicinity of the life table plots. Sampling is carried out on a weekly basis from mid-June until early August. These eight collection periods encompass most of the adult emergence, oviposition, and feeding larval periods. Each

---

* For colonies collected from invertebrate predator sample branches.

plot is equipped with two funnels and hoods. The hoods are secured over the funnels allowing for free movement of the screens over the funnels. The hoods are taped around the edges to prevent escape of CO_2 and pyrethrins. The CO_2 cylinders should be sunk in the bog to prevent over-heating and valves installed prior to sampling. A vial is attached at the base of the funnel by means of spring clips. The pole operator, after selecting and cutting a branch, should lower it gently, avoiding sudden movements which may dislodge insects on the foliage. Examine branch for larch sawfly colonies and egg shoots, remove and rear or preserve these with label and record in appropriate box for branch number and crown position. Be sure each shoot or colony is identified as to branch designation including the red identification label for vials and blue for preserved collections. The length and width of each branch is recorded and the branch is laid on the screen inside the hood and given 10 to 15 second spray of pyrethrin with the aerosol bomb. After closing the hood lid, set the timer clock for 2 minutes and open the CO_2 valve to the hood for the time interval set at 10 pounds of pressure on the gauge. At completion, cut CO_2 supply and set timer for 3 minutes. After a total of 5 minutes open lid, shake branch vigorously against the screen, remove branch, and discard. Push screen backwards and brush sides of funnel gently downwards to dislodge any insects sticking to the sides into the vial below. Remove vial, add appropriate label and clip in another vial for next branch. The supply from the 50 lb. CO_2 cylinders, if used for the indicated time interval will last for 3 to 4 collecting periods. When the regulator indicates approximately 200 the supply is very low and will run out before the full 20 branch sample is complete. Remove cylinder before using and replace with new supply, since after use the cylinder freezes in the bog and cannot be removed. To prevent insects sticking to the surfaces, the inner walls of the funnel have to be washed with gasoline periodically to remove the oily film deposits left by the aerosol spray. On return to the field laboratory the branch sample vials are kept separate from the colony collected vials for further sorting to remove debris, dust, lichen and leaves.

Field laboratory

Pour contents of vial into a tilted 15 x 10 white enamelled tray containing 4 to 6 oz. of water and gently separate leaves, lichen and debris from insects. Use magnifying lamps for greater visibility. Using forceps put all insects and spiders found in 1/4 dram shell vials, top with 70% alcohol, insert small blue label with plot and date outwards and in such a manner so as not to crush the insects in the vial and also allowing for a plug of absorbent cotton. Avoid over-loading the vials with insects (aphids, spiders) - use another vial with an identical label.

Predator Rearing

On arrival from the field, egg shoots (identified with a red label) with invertebrate predators (mirids, chrysopids, coccinellids etc.) are racked separately and rearings proceed in the same manner as described in egg rearings except for the following points of importance:

1. Keep fresh foliage (8 fascicles) and a supply of appropriate food for the predator in each tube; maintain records on date collected, progress to maturity (date moulted), date of death and records on number of eggs or larvae the predator has eaten.

2. When predator dies, point or preserve specimen in alcohol with necessary information on pinning label.

Laboratory, Winnipeg

In mid-January the insects from the branch samples are examined, identified and recorded. All predators and spiders are retained (Hemiptera and Arachnids) the remainder are discarded. The records are kept on Data form 20V with columns in the following order; Dereaocoris, Plagiognathus, Pinalitus, other mirids, Anthocorids, Pentatomids, Coccinellids, Lacewings, Syrphids, Nabids, Spiders, Mites, Larch Sawfly, other Sawfly, Geometrid, other lepidopterous larvae, other bugs, Ants, Wasps, Carabids, Elaterids, Bark Beetles, other Coleoptera, Aphids and others. All vials containing predators and records should be given to W.G.H. Ives for further examination and analysis after which the mirids are dried and pointed for shipping to Ottawa for identification.

The following provisional keys may be useful in separating some of the more common miridae and Chrysopidae.

Simplified Key to the Common Plant Bugs or Miridae Collected from Tamarack in Manitoba

1. Tarsal claws without a pair of prominent whitish membranous lobes between them 2

   Tarsal claws with a pair of prominent whitish membranous lobes between them 5

2. Anterior margin of promotum with a distinct even ring-like collar, hind tibiae with pale setae and pale wide or narrow rings 4

3. Rostrum reaching to fifth or sixth abdominal segment 8

   Anterior margin of pronotum without a distinct even ring-like collar, hind tibiae with dark setae on dark base and tarsal claws with only a pair of straight hairs between them . . . . . Plagiognathus sp.

4. Claws with deep cleft near base, anterior femora pale . . . . . Deraeocoris fasciolus Knight

   Claws with moderate or no cleft near base, anterior femora pale or black 5

5. Claws with moderate cleft near base, anterior femora black . . . . . Deraeocoris brevis Knight

   Claws without cleft near base, anterior femora pale . . . . . .Deraeocoris laricicola Knight

6. Posterior portion of head elongate, so that eyes are situated nearly their own length from pronotum . . . . . Collaria meilleurii Provancher

   Posterior portion of head not elongated 7

7. Hind femora long extending much beyond tip of abdomen second and third segments of antennae with white bands at base and middle. . . . . Phytocoris conspurcotus Knight

8. Head with distinct transverse carina, this represented by a row of bristles in the nymph . . . . . Pinalitus approximatus

   Hind femora not extended much beyond tip of abdomen, second and third segments of antenna without white bands at base and middle 9

9. Body clothed with simple hairs . . . . . .Ceratocapsus modestus (Uhler)

   Body clothed with two types of hairs . . . Ceratocapsus pumilus Knight.

Preliminary Key to Some Common *Chrysopa* Leach

1. Antennae with black and brown ring on second segment 2

   Antennae entirely pale 3

2. Face with Y-shaped mark between antennae which may or may not be connected with spots below the antennae if present . . . . . .*chi* Fitch

   No X- or Y-shaped black mark between the antennae, the broad black band between the antennae stop short of the vertex . . . . . .*oculata* Say

3. All veins entirely pale, or at most with only an occasional dark cross vein 4

   Gradates and some other veins marked with black or brown . . . . . *rufilabris* Burmeister

4. Small, very dark green specimens, ivory band very prominent over pronotum and generally so to tip of abdomen . . . . . *downesi* Smith

   Larger specimens, medium green, a narrow black band from eye to the mouth over the genae and only a little red adjacent to it . . . . . **plorabunda** Fitch

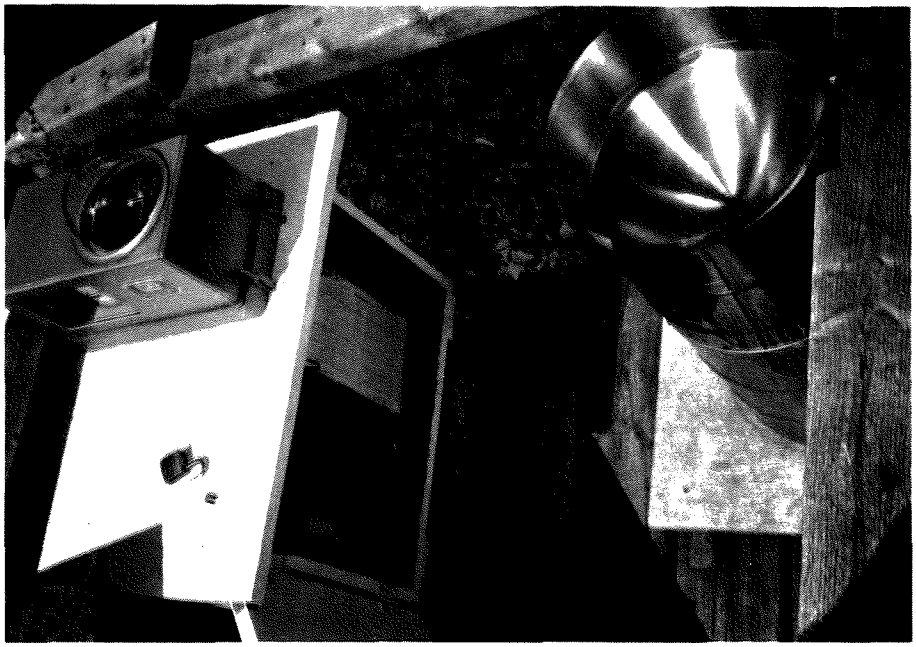


Photo C. Burdall

Meteorological tower instruments: recorder, pyrheliograph and tipping-bucket rain gauge.

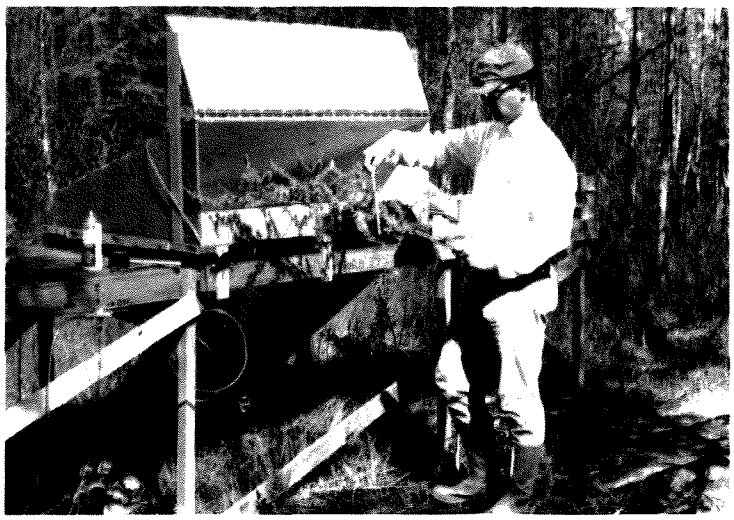


Photo J. Drouin

Invertebrate predator sampling hood and funnel.

Premature Larval Drop and Bessa Parasitism

The effectiveness of insect predators attacking the larval stages is difficult to evaluate. Of the larval parasites, a tachinid, Bessa harveyi (Tsnd.) is the most abundant in Manitoba and Saskatchewan. Other insect predators found attacking egg and larval stages are anthocorids, pentatomids, spiders and wasps. As a further refinement in the studies of larch sawfly fluctuations and mortality factors, oil drop funnels were first established at Rennie in 1961. Expansion of this sampling technique was continued until 1964. Currently the six life table plots are now equipped with 30 oil drop funnels each, which are serviced on a weekly basis.

Larch sawfly larvae that have completed feeding, are attacked by insect predators, are diseased or someway dislodged from the canopy by other factors, fall into a funnel at the base of the tree and are channelled into a galvanized metal box containing water and Carnea Pale Oil 21 as a preservative. The fallen larvae are suspended in the oil by a sieve and remain in this self-levelling device until removed.

Installation of traps

Oil drop funnel positions are established on the perimeter of the life table plots under the canopy of trees representative of the stand. Three numbered metal stakes are driven into the bog to support, by means of hooks, an hexagonal plastic funnel similar to larval drop funnels.

The tin boxes are set out in June according to their plot and position number. All containers should have a sieve. These are held by 4 wire hooks clipped over the lip of the box. The box is filled with water up to the stepped overflow lip with 2 inches of oil added next. The oil should be added very gently to prevent mixing and spilling through the overflow. The box is then placed into position, allowing approximately 3 inches from the apex of the funnel opening, then levelled and centered.

Servicing of traps - field

In servicing, lift the sieve from the box, let the oil drain, exchange for a clean sieve from the numbered honey pail and clip into position. Also check for oil depletion. Keep the current sieve upright in handling to prevent any loss of contents. Funnels should also be examined and any twigs, leaves or debris removed. Check the tree above the funnel for defoliation, and enter a check mark in the appropriate column in the weekly defoliation record of trees form provided for this purpose. This form is self-explanatory and divided into top 1/3 and

WEEKLY DEFOLIATION RECORD OF TREES ABOVE OIL DROP FUNNELS

PLOT RENNIE 1 DATE August 3 YEAR 1965

AMOUNT OF DEFOLIATION

Funnel Position No	Nil	TOP 1/3					LOWER 2/3				
		Branch Tips		Branches			Branch Tips		Branches		
		Few	Numberous	Several	Numerous	Complete	Few	Numerous	Several	Numerous	Complete
1				x						x	
2					x				x		
3					x				x		
4					x				x		
5		x					x				
6				x			x				
7				x			x				
8					x				x		
9					x				x		
10											
11											
12											
13											
14											
15											
16											
17											
18											
19											
20											
21											
22											
23											
24											
25											
26											
27											
28											
29											
30											

lower 2/3 of each tree examined. Overestimating defoliation in the early stages may occur but with experience an accurate estimate of these trees can be obtained.

In late August the sieves are removed and transferred to their respective honey pails. Gently pour the water from the self-levelling tin until the oil predominates, then empty oil into carrying cans. The oil is later strained to remove water and accumulated debris and put in a drum for re-use. All sieves, tin boxes, honey pails and carrying trays should be washed clean of oil crust and dirt film with gasoline taking all possible precautions against fire hazards, fumes and caustic effect to hands.

Servicing of traps - laboratory

Instructions for handling and recording contents in oil funnels are as follows:

1. Remove lids from honey pails and hang sieves inside pails to drain.

2. Set up two empty pails and two pails full of alcohol on newspapers.

3. Starting at number one pail, soak sieves and contents for a short period in alcohol and dump numbered pail into a drain pail.

4. Remove sieves and carefully examine contents over a pad of clean absorbent hand-towel paper. Set next sieves in to soak.
   (a) Remove, record and keep all larch sawfly larvae, keeping each category separate.

   (b) Remove, record and send all other larvae to Winnipeg.

   (c) Remove, record and discard, coccinellids, pentatomids and wasps.

(a) Larch Sawfly Larvae - These are divided into the following categories:

Instars - I II III IV early V mature V Holocremnus V

Condition
Healthy
Diseased - very hard, discoloured
Decapitated - head removed or only part of body left, if latter record as - hind 1/4, hind 1/2 as appropriate.

Pentatomid predatorized - shrivelled by predator removing contents.

Parasitized by Holocremnus - refers only to healthy mature V from Pine Falls and Riverton. These have shape and colour of mature V but are size of a IV instar.

Each larva is kept separate by condition and vial containing 70% alcohol for each funnel number with label indicating plot, funnel number, condition, instar and date i.e.:

R. 13		PF 20		R.25
healthy V 16/6/65	OR	decap. IV 16/6/65	OR	Holocremnus V 16/6/65

(b) Other larvae - record individually and place the larvae from all funnels (1-30) in a common vial containing 70% alcohol and label:

Plot
Date
Oil Funnels

Make out 4 copies of standard survey enclosure slip form and send 3 copies with the larvae to Winnipeg for identification. In remarks indicate oil funnel collection number. (Depends on week).

(c) Predators - record all wasps, pentatomids, coccinellids in appropriate column as adult (A), nymph (N) or larva (L) then discard.

As the 30 sieves are examined then numbered honey pails are returned in sequence to their respective carrying trays.

Examination of larvae at Winnipeg laboratory

The handling procedures for oil funnel larvae are similar to colony collections:

1. Check each larva for instar and parasitism by plot, date and funnel.

WEEKLY OIL DROP - LIFE TABLE STUDIES

Plot DARWIN 6 Date July 21, 1966 Collection No. Coll. IV

	Larch Sawfly Larvae												Predators					
	Decap.	Pent. or Pred.	Disease	Healthy									Cocc.	Wasps	Pent.	Other Sawflies	Geom.	Misc.
				I	II	III	IV	V	EV	LV	Holo. V							
1										1							1	1 Lep.
2										3								
3										3								
4			IV							8								
5		IV							1	14								
6										14			1A					
7										18							1	
8										3							1	
9										21						1		
10										11						2 anaplonyx		
11																		
12																		
13																		
14																		
15																		
16																		
17																		
18																		
19																		
20																		
21																		
22																		
23																		
24																		
25																		
26																		
27																		
28																		
29																		
30																		

2. Examine and record this data on 80 column sheets (A-332) following instructions on code card 06. Record plot, year, oil collection and sheet number on top right hand of data sheet. Opposite the entries remarks column, (right hand side) write in date of collection and funnel number.

Holocremnus parasite - Pine Falls, Riverton

This parasite species was first released at Pine Falls in 1961. Further releases were made in 1962 and 1963 at Riverton and the species appears to be well established at both release areas. As a result, handling techniques for oil drop larvae, and colony collections have been modified to obtain all available data.

Oil drops - Pine Falls, Riverton

Except for the following modifications all handling procedures are similar to those described under oil drops - laboratory.

1. Check each larva and class as normal or parasitized visually by head capsule size. This applies to third, fourth, fifth instar larvae only. Examine head capsule width under the ocular micrometer at 2.5 magnification (OPTON) and using conversion scale .385, establish head capsule measurement. Using the table of head capsule measurements for normal or parasitized Holocremnus, separate the larvae accordingly.

2. Record data on data sheets following instructions on code card 06.

LARCH SAWFLY LARVAE HEAD CAPSULE MEASUREMENTS FOR BOTH PARASITIZED AND NOT PARASITIZED BY H. sp. nr. nematorum

INSTAR	PARASITIZED				NOT PARASITIZED	
	H. sp. nr. nematorum			Mean	Normal	Mean
I	.48	to	.53	.53	.54 +	.56
II	.66	to	.74	.73	.75 +	.75
III	.90	to	1.15	1.02	1.16 +	1.09
IV	1.28	to	1.47	1.39	1.48 +	1.56
V	1.60	to	1.91	1.74	1.92 +	2.04

Based on individual rearings by J.A. Muldrew

CONVERSION TABLE WITH OCULAR MICROMETER AT 2.5 MAGNIFICATION (ZEISS OPTON)
USING .385 SCALE FOR LARCH SAWFLY LARVAE HEAD CAPSULE MEASUREMENTS

16.0 = .61	32.0 = 1.23	48.0 = 1.84
17.0 = .65	33.0 = 1.27	49.0 = 1.88
18.0 = .69	34.0 = 1.30	50.0 = 1.92
19.0 = .73	35.0 = 1.34	51.0 = 1.96
20.0 = .77	36.0 = 1.38	52.0 = 2.00
21.0 = .80	37.0 = 1.42	53.0 = 2.04
22.0 = .84	38.0 = 1.46	54.0 = 2.07
23.0 = .88	39.0 = 1.50	55.0 = 2.11
24.0 = .92	40.0 = 1.54	56.0 = 2.15
25.0 = .96	41.0 = 1.57	57.0 = 2.19
26.0 = 1.00	42.0 = 1.61	58.0 = 2.23
27.0 = 1.03	43.0 = 1.65	59.0 = 2.27
28.0 = 1.07	44.0 = 1.69	60.0 = 2.31
29.0 = 1.11	45.0 = 1.73	
30.0 = 1.15	46.0 = 1.77	
31.0 = 1.19	47.0 = 1.80	

Cocoon Populations

Larch sawfly that have completed feeding drop to the ground and spin cocoons in the first suitable location encountered. The numbers of larvae dropping from the trees are sampled by intercepting the dropping larvae by funnels and directing them into boxes containing a cocooning medium.

The function of the samples is three-fold: to provide a basis for estimating the cocoon population per acre; to provide estimates of cocoon mortality attributable to invertebrate predation, parasitism and prolonged diapause; to provide a source of adult sawflies for the measurement of fecundity.

Installation of traps

In estimating cocoon populations, two-square-foot fiber glass screen funnels on hexagonal metal frames are used to direct the falling larvae into a screen-bottomed sheet metal box containing moss as a cocooning medium. The galvanized metal boxes have an incurved flange at the top to prevent escape of the larvae. The box is covered by a 1/4 inch galvanized mesh lid to keep small mammal predators out. The metal boxes are permanently numbered and identified as to plot. The numbered boxes are placed to correspond with the larval drop position numbers.

(a) By the latter part of May each metal box is filled to 2/3 capacity with firmly packed sphagnum moss from a bog where no larch sawfly occurs.

The procedure for setting out these sampling units is as follows:

(b) During the first two weeks of June the funnels and boxes are set out. First the funnels stored on site are engaged in metal hooks affixed to the three numbered stakes representing the position. Check the funnels for tears, rents or rodent damage and replace if necessary. In past years, wooden stakes and cloth funnels were in wide use and although some remain these are gradually being phased out. The funnels are held in place on the three 2 x 2 posts with fencing staples.

(c) The metal boxes are then centered below the apex of the funnel allowing at least one inch clearance. In many cases, the boxes will have to be levelled with uncontaminated moss carried for this purpose.

Servicing of traps

As the season progresses personel servicing the emergence cages should examine all larval drop funnels and remove all dead leaves, twigs, etc. which may plug the hole at the apex of the funnels. This procedure should be strictly observed during the larval drop period (July and early August). The screen lid on the metal box should also be checked

and kept clean of the accumulating "mat" of frass and needles which may otherwise prevent the larvae from entering the box. Excessive frass should be removed from the boxes, being careful not to disturb the moss or lose any cocoons.

The 100 sampling units from each plot are picked up and brought to the field station during the last week in August. If the water levels are high in the plots when collecting, the boxes should be placed on the catwalks or other suitable dry location and allowed to drain for a short period. These can then be stacked 20 to 25 in a packsack and transported to the vehicle. Care should be taken in keeping the lids on and the boxes upright at all times. If boxes are tipped, lids may fall off and and the contents spill or, even if the lids remain on, cocoons may be lost through the large mesh of the lids. The boxes are stacked in the insectary.

Handling cocoons and recording data

The methods of handling the metal boxes to provide data for the estimation of cocoon populations and mortality are as follows:

1. The moss is carefully examined and all larch sawfly cocoons, dipterous puparia, and coleopterous and lepidopterous larvae, pupae and adults removed.

2. The number of cocoons from each tin are recorded for use in calculating cocoon populations and then placed in a plastic petri plate with some moist moss. No more than 25 cocoons can be placed in a single petri plate.

3. N.B. At all times the identity of the cocoons and records of their fate must be preserved. Be sure to label every container and identify every record with the plot and tin number.

4. The presence of other material is recorded and the specimens, in properly labelled petri plates, are passed to W.J. Turnock.

Mortality in Cocoon Phase

Before the cocoons from the moss boxes are packaged for overwintering, they are given a final sorting in the fall. In the spring they are again examined before incubation. After first year adult emergence is complete, the cocoons are dissected to determine the number of larvae in prolonged diapause.

Final sorting in fall

1. The cocoons from each tin are examined and divided into two groups (normal and small). Small cocoons indicate the presence of the parasite Holocremnus sp. nr. nematorum. Hereafter, normal and small will be kept separate and identified by the suffix N or S to the plot and tin number.

2. Each cocoon is examined and placed in one of the following categories: apparently sound; opened by an invertebrate predator; emergence hole of the parasite Bessa harveyi; containing a dead larvae. The cocoons in the last category are opened to see if they contain evidence of Bessa harveyi parasitism. In distinguishing between sound and dead cocoons, all but the obviously dead are classed as sound. In doubtful cases, assume the cocoon to be sound. Obviously dead cocoons may be recognized by the presence of solid, white or creamy mold emerging from the side (the presence of wispy web-like mould mycelia on the surface of a cocoon does not indicate a dead cocoon), by extreme turgidity of the cocoon, or by collapse of the cocoon. Flattened cocoons which are obviously dead should be carefully examined for evidence of Bessa holes after they are opened. The numbers in each category are recorded on the appropriate date sheet. i.e., Sound, Bessa hold, Dead with Bessa, Dead with Fungus and Misc. dead.

3. The apparently sound cocoons are packaged in dacron marquisette with moist sphagnum moss taking care to avoid squashing the cocoons and a label identifying the plot and tin attached.

After removal of all mortality any plot with over 600 cocoons should be considered as a source for dissection material. Remove one hundred (100) cocoons in the following manner:

a) Draw random numbers for box numbers for each plot.

b) Remove marquisette packages of cocoons in random numbers sequence until 100 cocoons are obtained per plot and record which ones have been removed.

c) Keep cocoons, plot and box numbers separate and package with moss.

d) Ship immediately to J. Muldrew for dissecting, keep in cool location.

4. Dissect cocoons and record the following:

a) Bessa parasitism as u, h, hs, hsm, s, sm, for each larva.

b) Mesoleius parasitism, including encapsulation.

c) Holocremnus.

Dissecting Technique for Living Larch
Sawfly Larvae used at the
Winnipeg Laboratory

(1) If the sawfly larvae are in cocoons remove them by cutting away a very thin longitudinal strip from each cocoon as shown in Fig. 1.

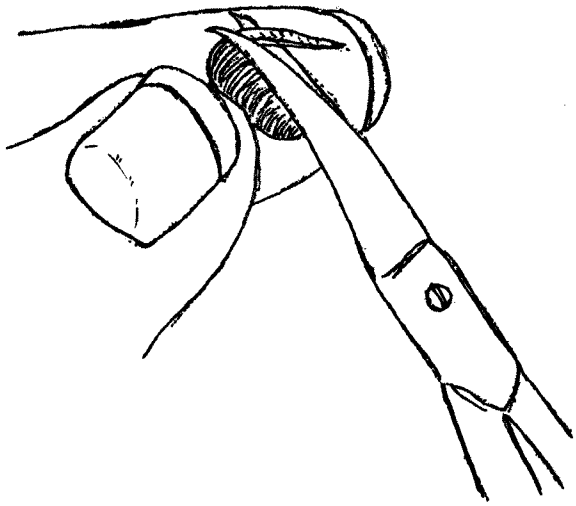


Fig. 1.

Then scoop out the sawfly larva.

(2) Hold the larva between the thumb and index finger as shown in Fig. 2 and cut off the head capsule.

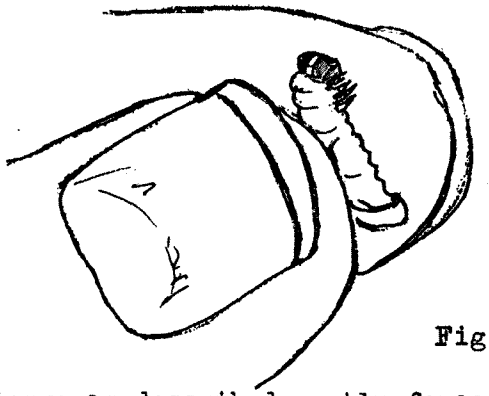
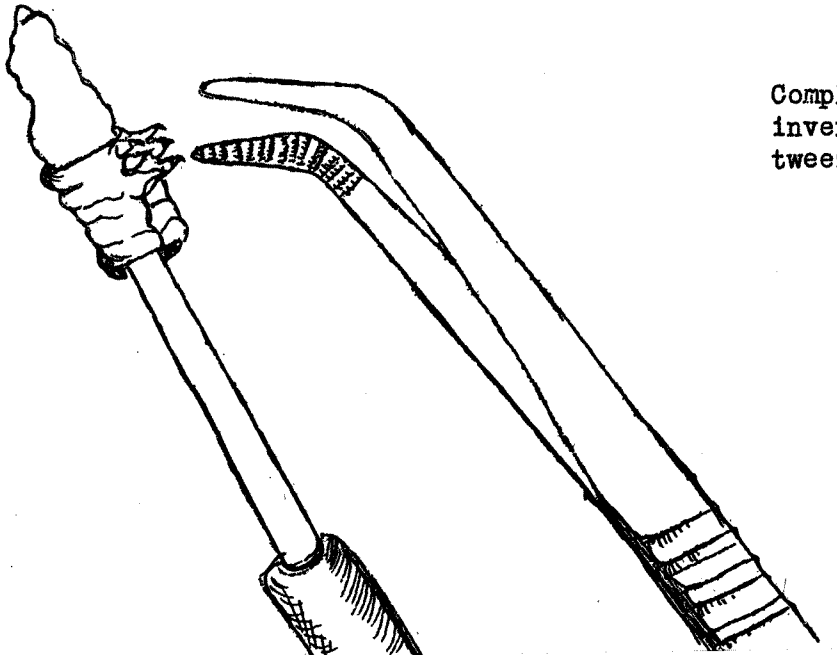


Fig. 2.

(3) Still holding the larva as described gently force a straight probe into the integument adjacent to the anus and begin turning the larva inside-out along this probe. The larva will now appear as in Fig. 3.



Complete the inversion using tweezers.

(4) Transfer the inverted larva to a glass dissecting tray by holding the posterior end of the larva down with a probe and withdrawing the other probe.

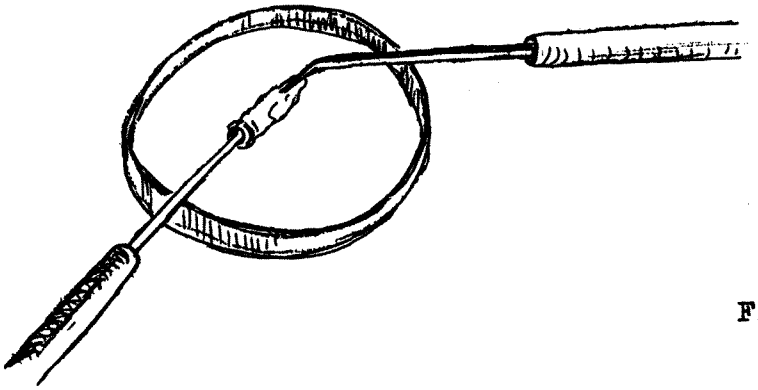


Fig. 4.

(5) Using a medicine dropper place two drops of water on top of the inverted larva. Using the binoculars at approximately 10 x magnification place the dissecting dish containing the larva on the stage of the binoculars over a black background. Using a straight probe and a curved probe carefully separate the gut and loose fat body from the rest of the larva and examine carefully for M. tenthredinis eggs or larvae by teasing the tissues with the probes. Then holding the integument down with the straight probe as shown in Fig. 5.

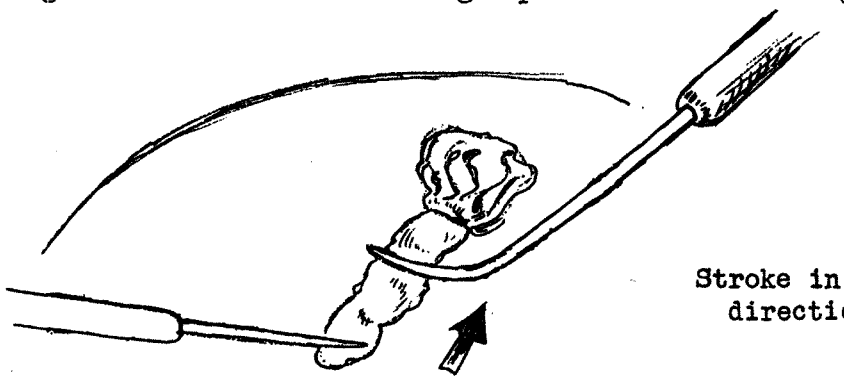


Fig. 5.

Examine the scrapings for M. tenthredinis eggs or larvae by teasing them apart with the probes. If it is desired to preserve the parasite material found, this can be transferred from the dissecting tray to the preservative using a medicine dropper.

For finer work such as dissecting away the capsules from the parasite eggs, etc., 30 x to 60 x magnification should be used.

5. The remaining packages of cocoons are layered between sphagnum moss in boxes with screen tops and bottoms. These boxes are stacked in a well-drained, shaded location, covered with about six inches of moss and left for the winter.

Instructions for dissecting larvae and forms for recording mortality data for cocoons examined in the fall are given on the following pages.

Handling in spring and during incubation period

1. During the last week of May the boxes are opened and the packages brought to the insectary. The cocoons in each package are re-examined and recorded as in step #2 of fall sorting, using the form shown on the next page.

2. "Moist" moss, i.e. with the right level of moisture for larch sawfly cocoons, feels damp but if a small handful is squeezed, no water should drip out.

3. The apparently sound cocoons are placed in petri plates (maximum 25 per plate) with moist moss and labelled with plot and tin identification.

4. The petri plates containing cocoons are placed in the iceboxes partially buried in the bog near the field station.

5. The cocoons should be examined twice weekly until the first sawfly adult is observed and then daily until emergence has ceased. In examining the cocoons, care should be taken to avoid long exposures to air temperature: only one tray should be removed from the iceboxes at a time.

6. Each petri plate should be carefully observed from the outside for the presence of parasite puparia, sawfly or parasite adults, or dead cocoons. Any collection showing such evidence should be opened and the following steps taken: (a) parasite puparia - place in small petri plates with moss, label appropriately and given to W.J. Turnock. Locate the cocoons that they came from and cut them open to see if another puparia is inside; (b) parasite adults - remove and place in a plastic vial with a label, identifying plot, number and date. Identify the species, record in book and treat each species as follows:

Bessa harveyi - given to W.J. Turnock
Mesoleius tenthredinus - Riverton and Rennie plots, report to W.J.T.; other plots, kill, pin and label.

Diagrams of dipterous puparia that may be encountered are shown on the next page.

COCOON SAMPLES: Fall mortality

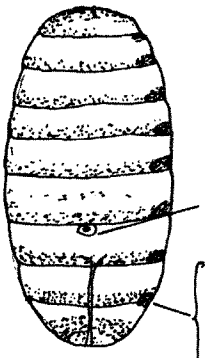
Plot RENNIE 1 Year 1964 Date 2/9/64

Cocoon size: (Normal) or ~~Small~~ Examined by: MJP

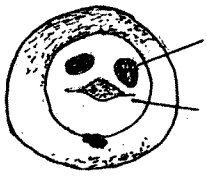
No.	Total cocoons	B. harveyi emerged	Insect predators	Miscellaneous mortality			Total sound	Package Number
				Fungus	Dead B. harveyi	Unknown		
1	1	1					0	
2	2						2	contains ant nest
3	11	4				2	5	
4	6	1				1	4	
5	1		1				0	
6	4		1				3	
7	2	1	1				0	
8	2						2	
9	19	7					12	
10	1					1	0	
11	10	3					7	
12	14	2				1	11	
13	3						3	
14	11	5				1	5	
15	4	1					3	
16	39	7	2			18	12	
17	19	4				1	14	
18	12	2	2			3	5	
19	9	4				1	4	
20	5	1	1				3	
21	5	3					2	
22	4						4	
Sub ∑	184	46	8	-	-	29	101	

LARCH SAWFLY PARASITE PUPARIA

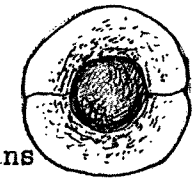
Bessa harveyi (Tnsd.)



lateral view

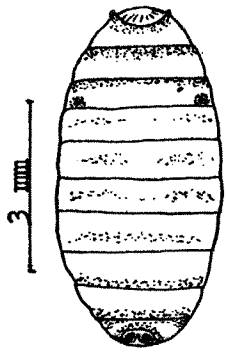


Posterior view

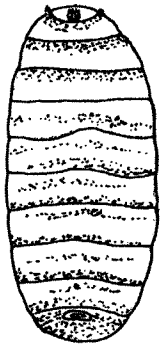


Anterior view

Myxexoristops stolida stein.

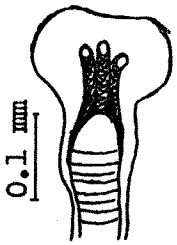


dorsal view



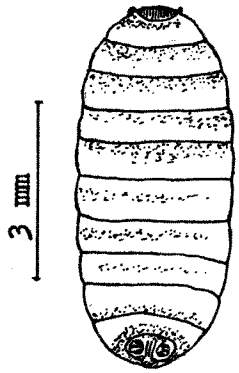
ventral view

Posterior stigma



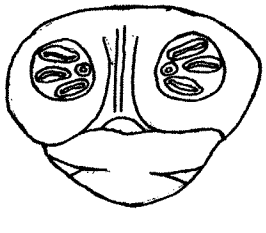
Anterior stigma

Hyalurgus lucidus Meig.



dorsal view

ventral view



Posterior stigma

Anterior stigma

Holocremnus sp. - sex each specimen. Most of these will be placed in a holding cage for later release. This cage should contain honey solution, water and broken raisins. However, we would like a series of 10 ♂ and 10 ♀ specimens from each of the Pine Falls and Riverton plots. Specimens for this series should be selected, killed, pinned and labelled from emergents at the beginning, mid and end of the emergence period.

Other species - kill, pin and label.

7. Sawfly adults - find and discard the empty cocoon and place the adult in plastic vial with a label showing plot, tin, date and an identification number and return to the icebox for 24 hours. Then each adult should be weighed to the nearest 0.2 mg. In using the Roller-Smith torsion balance note that the divisions on the main scale are in units of 2 mg. and the vernier scale allows measurement to 0.2 mg. In setting up the balance be sure to level it and check the zero reading for the empty pan. Recheck zero reading after every five weighings. After weighing, the adult is preserved in 10% formalin solution and its label, with the weight also recorded, placed in same vial with weight and adult number visible. N.B. Use a HB pencil for writing on labels.

On Saturdays weigh and preserve the Saturday emergences without holding for 24 hours. This will reduce Sunday work load and give a comparison for converting old data. Do only for plots with high adult populations; 8. Dead cocoons - only cocoons that obviously contain dead larvae should be removed from rearing, if any doubt is present, leave the cocoon alone. Dead cocoons should be opened and the presence of evidence of parasitism recorded. The date and numbers of adult sawflies, parasites, puparia and dead cocoons are recorded in the appropriate record books.

When no emergence has occurred for two weeks, every remaining cocoon is opened and the contents recorded as: dead, dead including evicence of parasite attack, or living eonymph, pronymph, pupa, or adult. Living sawflies are examined externally and scars denoting parasite attack are recorded. They are then dissected for internal evidence of parasitism. This work will be directed by J.A. Muldrew. When the remaining cocoons have been opened the totals for each category should be entered and checked against the initial number of cocoons. All data should be recorded on the forms shown on the following pages.

The preserved adults will be stored in the refrigerator until they and the recorded data can be given to R.J. Heron, who will supervise dissections to determine adult fecundity, by the procedure outlined in the next section.

COCOON SAMPLES: Sawfly and parasite emergence

Cocoon size: (Normal) or [redacted] Plot: Picnic Year 1964

Date

No.	Species	14/6	15/6	20/6	26/6	5/7	19/7	20/7	22/7										Total
2	Sawfly				1				1										2
	B. harveyi																		0
	Other par.																		0
3	Sawfly							1											1♀
	B. harveyi	2p.																	2p.
	Other par.																		0
4	Sawfly						1												1
	B. harveyi	1p.	1p.																2
	Other par.																		0
6	Sawfly					1					1								2
	B. harveyi																		0
	Other par.																		0
8	Sawfly			1															1
	B. harveyi	1p.																	1
	Other par.																		0

Adult Fecundity

The determination of the reproductive capacity of the larch sawfly is facilitated by the occurrence of obligatory parthenogenisis in this species. Adults are capable of oviposition within less than a day of emergence from the cocoon and will oviposit without intake of food or water. The females are capable of laying their full complement of mature eggs but the extent of oviposition is extremely variable under cage and laboratory conditions. Counts based on dissections of day-old adults eliminate the vagaries of oviposition. They give a figure which represents the full potential egg production. (Heron)

Each of the ovaries of the larch sawfly consists typically of twenty ovarioles of the polytrophic type. Each ovariole usually consists of one, two or three mature ova plus one or more immature ova in various stages of development. Immediately proximal to each immature ovum is a follicle containing a group of trophocytes (nurse cells). The trophocytes degenerate as the ovum approaches full development. Differences between the ova and trophocytes during dissection is aided by the use of a fat stain, Sudan III. Recording the numbers of mature and immature ova these are classified with respect to the degree of development as follows:

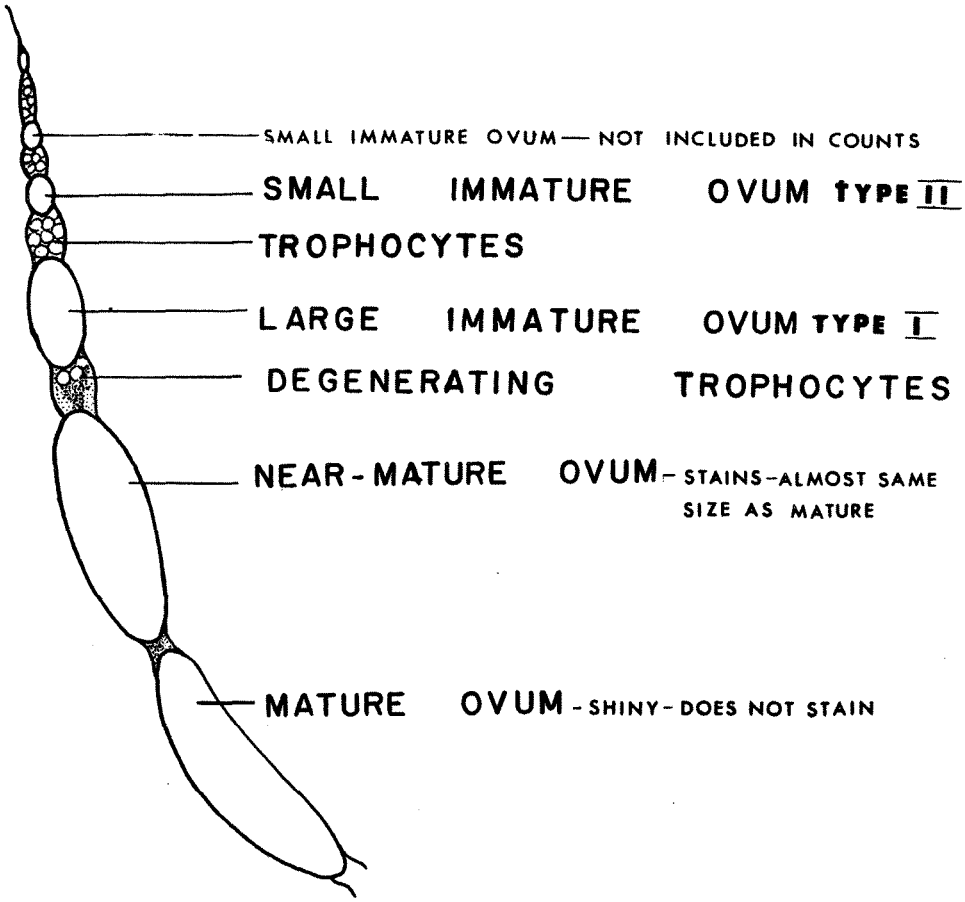
1) Mature Ova - These are fully formed eggs and do not stain with Sudan III due to the presence of the chorion. The eggs are white and the surface of the chorion very shiny. There are no trophocytes associated with the mature ova.

2) Near Mature Ova - These are as large as the mature ova but take up Sudan III dye to varying degrees as the chorion has not been completely formed. They also lack the shiny appearance and the trophocytes have completely, or partially degenerated.

3) Immature Ova - These take up the Sudan III stain readily. A group of trophocytes is situated proximal to each immature ovum. These also fall into two different types.

    Type I - the ovum is at least as large as the accompanying group of trophocytes.
    Type II - the ovum is less than twice as large as the accompanying group of nurse cells.

Those immature ova which are smaller than their accompanying group of trophocytes are not included in the count. (Heron) Ova in various stages of maturity are shown on the following page.


SMALL IMMATURE OVUM — NOT INCLUDED IN COUNTS
SMALL IMMATURE OVUM TYPE II
TROPHOCYTES
LARGE IMMATURE OVUM TYPE I
DEGENERATING TROPHOCYTES
NEAR-MATURE OVUM - STAINS-ALMOST SAME SIZE AS MATURE
MATURE OVUM - SHINY - DOES NOT STAIN

The materials required for the dissection of larch sawfly are:

1) granular histowax
2) beeswax
3) Sudan III stain
4) Scalpel or dissecting scissors
5) Pins, #3 size
6) One microscope slide
7) Squeeze bottle of water
8) Microscope

Preparation

An equal amount of histowax and beeswax is melted in a beaker which is immersed in a boiling water bath. Once the wax has melted a few drops of Sudan III in 95% alcohol solution is added to give the wax color. The colored wax is then poured into small petri plates and allowed to harden. The wax is colored to present a good background for dissection.

The adult female sawfly is secured in the centre of the petri plate by a pin through the centre of the thorax. A second pin is placed at an angle through the tip of the abdomen and into the wax. Remove the wings. Gently lift the carapace and make an incision running from the postnotum to the 7th tergite of the abdomen and fold the covering back to each side. Secure each side to the wax with pins. Stain the ovaries with a few drops of Sudan III and allow it to "take" for a few seconds. Gently rinse the excess stain off and remove the ovaries separately to a drop of water on the slide. The ova are then counted under the microscope following the outline. Enter the counts of each of the classes on an appropriate work sheet.

Amount of Foliage in Plots

This technique provides a basis for comparing the intensity of sawfly infestations in stands of larch differing in the volume of foliage available and for evaluating the effect of the insect on the host tree. Foliage sampling is carried out periodically during low or high population levels.

Method

The sampling method is based on foliage weight, which gives a statistically acceptable estimate of foliage production. Sampling is carried out in early summer after the growth on the host is complete but while the needles and shoots are still soft. Foliage weight increases as the season progresses. If more than one plot is being sampled, sampling should be completed within a two-week period.

Random numbers are selected in the plot to be sampled for forty trees allowing 2 or 3 spares in case of mortality. Tree heights and crown depths are measured using the pole pruner method described in branch sampling. Random number tables are then used to determine location, by height and cardinal points, for 2 branches from each of the 3 crown levels in each tree.

The sample branches are cut with the pole pruners at or as close as possible to the pre-selected height and cardinal point. The branches are lowered to the ground avoiding any loss of foliage or breakage. The number of shoots on each branch are entered in the field record books. Each branch is cut, avoiding any loss of foliage, into pieces small enough to fit into the cloth bags, which are then tied and tagged and hung until air dry. Branch counts should then be made in the established crown depths in order to obtain the foliage production per plot.

Laboratory procedure

Hand sorting and soil sieves (mesh 20, 50, 100) were used to separate all the tamarack foliage from the bark, lichen, dust and twigs. This method was time consuming. The Engineering Research Service in Ottawa, developed on request, a mechanical sorter which is considerably faster and more efficient. The bags are opened, and the branches and foliage dumped into the hopper. Invert the bag and remove and shake out whatever needles or foliage remains. Tilt hopper contents into the rotating drum and start machine with the foliage receiving trays in their proper positions. After the drum contents have gone through the shaker examine branches in the waste bin and remove any foliage remaining. To avoid excessive debris and dirt in the final foliage sample remove the larger branches from the hopper as these are generally well coated with lichen. Hand pluck the foliage if necessary. It may be necessary to sort some branches twice to remove all the foliage.

Empty the contents of receiving trays on a clean, white sheet of paper, check and remove any dirt or debris. Dump the foliage into a pre-weighed tin recording the tin weight, tree and branch number. This foliage is then oven dried at 105°C for 48 hours and weighed. Instructions for operating the foliage sorter are as follows.

Instructions for operation of tamarack needle sorter #6048

The purpose of the Tamarack Needle Sorter is to separate tamarack needles from the twig debris and dust which is with them as collected. The machine consists of a feed hopper, a feed drum, a shaker shoe and drive, and three collecting drawers.

Hopper. The hopper is mounted on the left-hand side and feed directly into the feed drum. Hinges allow it to be swung over the feed drum for storage.

Feed drum. The feed drum is designed to break up needle clusters and meter them onto the screen in an even flow. Rate of flow is controlled by the variable speed gear box on the right-hand side. Speed selection should be governed by the cleaning rate of the screen.

Shaker shoe. The shaker shoe is made up of two screens, the upper one being made up of slots 1 inch long and .040 inch wide and the lower of .050 diam. holes. The upper screen allows needles and dust to pass through but carried twig debris onto the collecting drawer at the front of the machine. The lower screen separates out organic dust and small or broken needles. Chains are fitted over the screen to accelerate the screening process and to break up clusters. The chains on the upper screen are adjustable. The speed of the shoe is 350 cycles per minute and the throw is 3/4 inch.

Drawers. Four drawers are supplied with the machine. Only three are used at any time. This allows the machine to be operated from the left or right side. Bullet catches position the drawers.

Lubrication. Four grease nipples are located on the eccentric shaft. An oil hole is located in the drum shaft. The variable speed gear box is oil-filled. All other moving parts require no lubrication.

Motor. 115 volts - 60 cycle 1/4 h.p., protected by a thermal overload switch.

Operation. Before placing the sample in the hopper, the machine should be started and the feed drum stopped. After the sample has been placed in the hopper and pushed into the feed drum, a suitable flow rate can be obtained on the feed drum speed selector. Sieving action over the top screen should be smooth, with most of the needles falling through the screen in the first two-thirds of the screening area. With some samples of needles, e.g., those that are not entirely dry and those that have curls on the ends, plugging of the lower screen will occur. This will not hinder the sieving action but will cause some needles to fall into the dust drawer. When the sample is finished, this screen should be brushed down with a small brush.

At this point, it will likely be found that there are some needles in the debris drawer and in the dust drawer. These samples should be run through again slower than the original sample.

If the dust in the sample is negligible, a board may be substituted for the lower screen. If due to some accident the screens are broken, the lower screen material is available commercially, but the upper screen was custom-made in the Engineering Research Service shop, Ottawa.

Microtopography in Sample Plots

Sample measurements of the microtopography in the sample plots are obtained at intervals of several years by the following procedure.

Once the stakes have been levelled, a five piece jig is set up on each grid, in turn, as follows:

1. The double notched bars are placed parallel to the base line with the shoes fitting squarely on the stake tops. Do not apply pressure when fitting the jig as the stakes may be thrown off level. The top of the stake in the shoe must be in contact with the bar. Fit spacer bars onto the steel pegs at the ends of notched bars to complete six foot square.

2. Place measuring bar, with ruler slots, over retaining pegs at position one.

3. Measurements are taken from left to right at one foot intervals. This yields 36 measurements per grid.

4. Drop yardstick to ground contact through each slot without applying additional pressure. Contact must be with ground and not matted grass or twigs.

5. Readings are taken to the nearest half inch and recorded from left to right as follows:

31	32	33	34	35	36
30					25
19					24
18					13
7					12
1	2	3	4	5	6

Also indicate in record book grid and line number. (See plot outline).

6. The jig utilized in measuring the grids offers a wide degree of flexibility where trees, root crown, emergence cages or larval drop positions are encountered. By shifting the spacer bars around these obstacles, exact measurements can still be taken while retaining continuity. In such a case, when measuring the sampling unit where the tree, root crown, hummock etc. occurs, it should be indicated as such above the recorded measurement. (i.e. Tree 20.5). In cases where the sampling unit falls on a duckboard, which cannot be removed, take the measurement

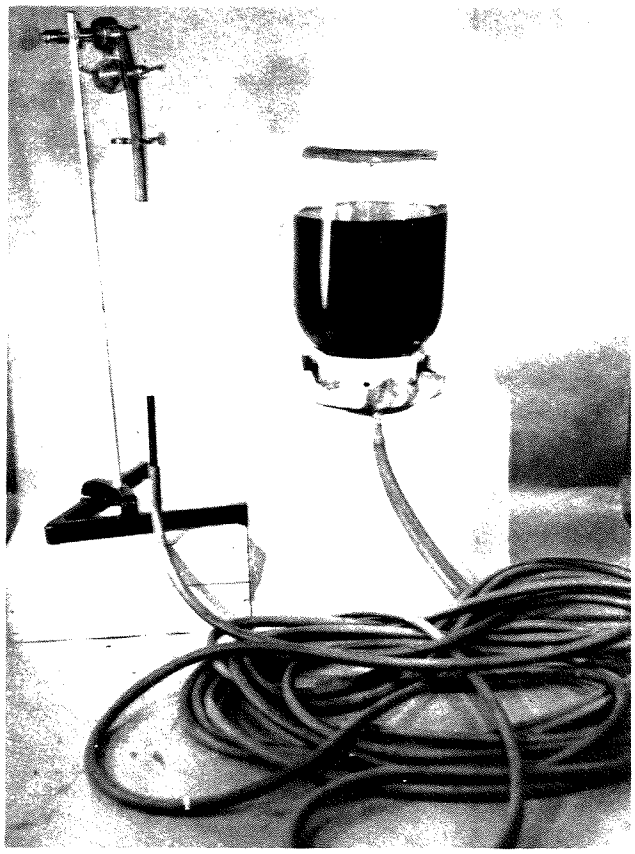


Photo B. McLeod

Apparatus for levelling tops of stakes prior to topographic measurements.

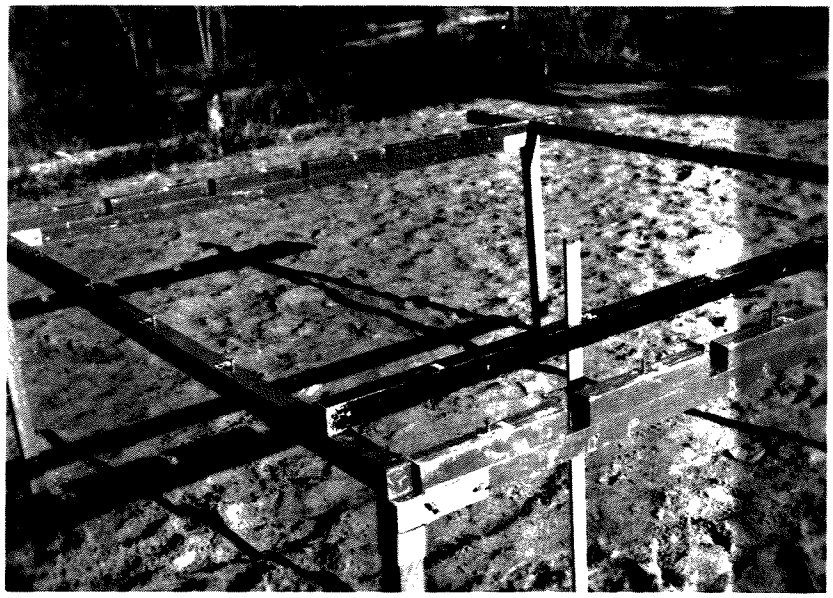


Photo C. Buckner

Jig for making topographical measurements.

Water Table Fluctuations

The larch sawfly is subject to considerable mortality from flooding in the larval and cocoon stages. These measurements provide data from which to determine the effect of fluctuating water levels on sawfly survival. Water levels are taken throughout the year unless the pipes freeze. Weekly readings are taken during the field season at all seven plots.

Water level measurements are made with 1/2" square, 60 inch long hardwood stick with 1-inch graduation indented along the length and numbers stamped at 6-inch intervals (6, 12, 18, etc.). Readings are taken to the nearest 1/2 inch. The thumb should be placed at the last reading taken and the measuring stick lowered into the water level pipe. If no water line is visible at the tip of the stick, repeat the operation allowing another inch until the water level is reached. Enter the reading (to nearest half inch) in the field record book under the appropriate position (NW, SE, or 2, 3, etc.).

During measurements from mid-March to mid-May, pipes previously reported as frozen should be checked at that level. Spring run-off causes water to flow into the pipe above the ice cell giving a high and false reading.

Phenology - Whiteshell Field Station

The measurements of shoot lengths on two tree species at the Whiteshell Field Station which is used as one of the reference points for a phenological survey in regions of Manitoba and Saskatchewan are taken annually.

Procedure

1. Locate reference station along lakeshore on white spruce and tamarack regeneration.

2. Select 5 trees of each species to be measured. Trees should be small, ranging between 8 to 20 feet and do not necessarily have to be in the same stand. Select trees that are open-growing or otherwise exposed and in tagging, select the western side.

3. Tag 3 shoots of each tree at or about eye level for ease of locating. Use colored twist-em tags or wooden marking tags with tree and shoot number marked on with felt marking pencil.

4. Starting in latter part of May, measure bud length of dominant branchlet of tagged branch in millimeters. All measurements, of shoot length are then taken from the base of this bud. At end of season bud length is deducted. Measurements are taken twice a week until end of

Phenological Survey for Winnipeg

and Whiteshell Staff - Shoot Growth Measurements

Location Whiteshell Field Station Grid G-015-216

Elevation _____ Year 1966 Observer J.A. Drouin

Tree species White Spruce Tree No. 1

Miscellaneous Dates: Buds swelling _____

Scales parting June 3 Greenbud tips _____

Scales falling June 7 Pollen falling _____

Current Shoot Length in Mm.

Date	Branch No.				
	1	2	3	4	5
June 3	36	31	38	29	10
June 7	48	44	57	46	15
June 10	58	53	72	57	20
June 15	79	77	103	83	30
June 20	97	108	152	126	46
June 24	97	108	162	131	47
June 29	97	108	163	132	47
July 5	97	108	164	132	47
July 8	97	108	169	132	47
July 11	97	108	169	132	47
July 18	97	108	169	132	47
July 22	97	108	169	132	47
*Aug. 1	85	94	156	123	37
**Aug. 1	5	6	5	5	2

* Measurement to bud

** Bud measurement only

W-48

July or until 3 consecutive measurements produce the same results. Phenology data should be transferred from field record book to pheno form W.48 at the end of the season.

5. As the season progresses spraying with DDT may be necessary on both white spruce or larch to prevent defoliation of tagged shoots by the yellow-headed spruce sawfly or larch sawfly.

MISCELLANEOUS

Insectary Rearings

The majority of rearing programs carried on at the Whiteshell Field Station are the responsibility of one assistant whose duties include rearings for the larch sawfly life table studies and experiments for individual research officers. Life table rearings are repeated annually and require a careful, experienced person to maintain continuity from year to year.

Egg rearings

These provide the basis for estimating the annual mortality of egg populations in the life table plots. Shoots containing eggs are collected weekly by the servicing crews and handled with care to assure normal hatch. On collection in the field the shoots are placed in egg rearing tubes with date of collection, plot and other information relating to predators or branch sampling code if applicable. See section on "Egg and larval mortality, shoots containing eggs and handling procedures."

Predator rearing

These provide data on predators (mirids, chrysopids, coccinellids, spiders, etc.) in relation to sawfly eggs and larvae. The procedure for handling the shoots is similar to that used in egg rearings with additional points of importance. See predator rearings section under "Invertebrate Predators".

Mass rearings

These supply the adults for the next year's experimental rearings. Mass collections of fourth and fifth instar larvae are made in the field and the larvae are caged, fed until mature and allowed to drop and spin cocoons in moss provided. Further rearings of these cocoons provide

adults, eggs and larvae for numerous other projects on life table studies. The handling procedures are outlined below.

The larvae are set up 1,000 to a rearing cage, fed until mature and allowed to drop and spin cocoons in the moss provided for this purposes. Mass collection dates vary from year to year depending on weather conditions but field checks should be made in the latter part of July until assured that the bulk of the populations are in the fourth or fifth instars. The larval colonies are then collected, with a minimum of foliage, using sleeve cages, then transferred to rearing cages for transporting to the field laboratory and handled as follows:

1. Rearing cages with adequate moss and foliage should be set up prior to arrival.

2. Check daily for condition of foliage, water and moss humidity. Replenish as needed. Discard dead or diseased larvae.

3. At completion of larval feeding let cocoons stand for a week to assure cocoon spinning is complete.

4. Sort out and set cocoons in refrigerator trays in marquisette packages layered in moss.

5. In September, layer marquisette packages in moss in screened containers and store under moss in semi-natural environment.

Bessa harveyi rearings

These studies are under the supervision of Dr. W. Turnock. Procedures as follows:

1. Check Bessa emergence daily, record sex and date emerged of each adult. Set the adults in mating cages with sugar cubes and cotton wads soaked in honey and yeast solution.

2. After several days in mating cage set two females and a male in a cage with a spray of foliage having 10 fourth- and 10 fifth-instar larvae on same.

3. Each cage should have wads of absorbent cotton soaked in 15% honey and yeast solution. Replenish supply daily.

4. Replace dead Bessa and record date of death.

5. Check larvae daily for parasitism and record same. Place each parasitized larvae in a jelly jar (screen lid) with moist moss and sufficient foliage.

6. Check and record survival and development of each parasite and its host daily.

Colony collections

These colonies are collected weekly by the servicing crews and preserved in alcohol. See section on "shoots associated with larvae" for further information.

Oil funnel larvae

The oil funnel larvae handling procedures are similar to colony collections. See section on "cocoon populations" for further information.

1. Check each larvae for parasitism by plot date and funnel. Keep each separate and in sequence.

2. Record this data on your 80 column sheet (A-332) following instructions on card 06. Record plot, year, oil collection and sheet number on top right hand of data sheet. On opposite side (right-hand side) of entries write in date of collection and funnel number.

METEOROLOGICAL EQUIPMENT

Analogue Recorder

This portable instrument is the 'heart' of the meteorological tower complex. It operates on a 6 volt dry cell battery and simultaneously records miles of wind, gust velocity and amount of rain. Extreme care should be exercised by the servicing personnel to ensure that all systems are operative. Omission of any of the necessary adjustments and checks at time of servicing may result in the loss of one or all of the recorded events for the time elapsed between servicing. Any malfunction, must be reported to the party chief, who will make necessary adjustments or repairs and enter these in the plot record book.

Operation and maintenance

Moving-coil measuring element - The permanent - magnet, moving - coil measuring element records current flow generated by the self-generating gust anemometer. The staff of the moving coil carries the pen. The measuring element develops sufficient torque to draw the record accurately on the moving chart. The top of the measuring element forms the receptacle for the inkwell and has two drain tubes to drain off any spillage. A canopy immediately below the pen fork protects the top bearing against ink spillage and prevents any material from travelling down the staff to current-carrying parts.

Zero adjustment - If the pen does not come to rest directly on the zero line of the chart when the gust recording anemometer is stopped or disconnected, the zero should be reset by slight adjustment of the lever located at the bottom of the case. To set zero position accurately, the pen element must sit properly in the pen fork, full of ink, and correctly balanced. A properly balanced pen primed with ink should bounce up off the chart paper when the pen table is lightly tapped with the finger. Once the pen is balanced, zero the movement by tapping the pen table and moving the zero level until the pen point rests exactly on the zero line of the chart. If an adjustment to pen balance is necessary, turn the small weights on the pen element nearer to or farther away from the knife-edge pivot of the pen fork. The weights are locked in position by screwing them tightly against each other.

Chronograph pens - The chronograph pens record rainfall on the right side and wind mileage on the left side of the chart paper, viewing the instrument from the front. The pens are actuated by a small electro-magnet assembly. The pens move about 1/10 inch towards the outer edge of the chart when energized and return to normal "off" position when voltage is interrupted. When placing the pen - inkwell assembly in the bracket the "V" in the tail of the assembly must engage the lever arm of the electromagnet. Check the pens by pushing the lever over with the point of a lead pencil or/and tripping the rain gauge.

Spring chart driver

Operation and care - The instruction plate on the front of all standard power drives shows the path travelled by the chart, gear changes for each standard speed and instructions in starting and stopping the drive. The change gears are stored on a clip at the upper left hand corner. Change gears currently in use are green in colour for both driver and driven having 60 and 30 teeth respectively, providing a chart speed of 6 inches per hour. The driver (60 teeth) is located on the bottom shaft. When setting up the recorder, check to see that the knurled nut holding the gears is tight, as they may loosen in handling and during transit.

Winding the springs - To wind, insert the square end of the winding crank into the winding arbor, push the arbor in as far as it will go and, at the same time, turn steadily in a clockwise direction. When the springs are fully wound, the winding crank will refuse to turn. Be sure the chart drive is fully wound before stopping. A partial turn in the reverse direction and at the time withdrawing the crank, completes the winding operation. If the springs are unwound completely, it requires about 110 turns of the crank to rewind them. The chart drive would then operate for 8 days. During weekly servicing approximately 54 to 65 turns are required to replace the energy under normal operation.

Starting and stopping the chart drive - The chart is started by raising the control lever on the left side from the stop position to the hour feeds mark. A white target, visible through the small window at the left edge of the instruction plate, moves up and down when the drive is running. If the drive does not start immediately, move the control lever up and down a few times.

Chart installation - All charts are 6 inches wide and have perforations along each edge at 1/2 inch intervals. Each chart is 103 feet long, the useful length being 100 feet; three feet are allowed for threading up the recorder and waste in starting at proper time mark. Charts currently in use are D-4313. The step-by-step procedures in charting the drive are as follows:

1. Press down on either right or left re-roll latch near bottom of case, and remove re-roll roller.

2. Remove chart roll arbor by lifting and pulling forward. Centre paper roll on arbor with elongated chart perforations to right.

3. Snap arbor with new chart into slots. See that chart roll turns freely.

4. Cut end of chart paper to "V" shape. Feed chart into slot marked "Insert End of Chart Here".

5. Push chart into slot until paper hangs over top drive roller.

6. Carefully pull chart down while turning drive roller knob so roller pins engage chart perforations.

7. Snap re-roll roller in place (gear end to left) and insert "V" end of chart into roller slot.

8. Turn re-roll roller back 1/4 turn to release brake (window-blind action). Advance set knob, see that chart is straight and taut.

9. Turn knob ahead until desired time appears under pen elements. Pens should be in position prior to this final charting step.

10. Write on chart, name of plot, date and time started (C.S.T.), and initial. This also applies when stopping the chart during weekly servicing. After stopping the drive, write on chart, plot date and time stopped (C.S.T.), and initial. Any other information pertinent to time accuracy, adjustments, machine failure, pen tracking and testing, should be written on the chart.

11. Chart removed should be returned to a box with plot, date (and year) started and date stopped stamped on the top of the lid for future identification.

Inking the instrument - The pen element and inkwell can be removed or inserted easily. The inkwell is held securely in place in the cavity in the measuring element top assembly. To fill, proceed as follows:

1. Swing scaleplate upward, grasp front plastic lip of inkwell, and lift well up and out of instrument.

2. Fill inkwell slightly over half full. Use filler supplied. Carefully replace well under retainer clip.

3. Seat knife-edge pivot of pen firmly between fork assembly with pen tube resting in well. Pen will remain off chart until filled with ink.

4. Compress pen-filler bulb, insert pen point into hole at rubber tip, release pressure slowly until ink appears in glass tube.

5. Check well every week when servicing instrument and top off if necessary.

Inking the chronograph pens is carried out in the following manner:

1. Remove the pen - inkwell assembly, unscrew the knurled inkwell cover and fill approximately two-thirds with the filler. Screw on top and replace inkwell very carefully.

2. Fill the pen element using the pen filler, being careful not to remove too much ink from the inkwell.

3. Be sure that the tail of the pen - inkwell assembly engages the lever arm of the electromagnet. Check pens for trace by tipping the rain gauge bucket and pressing the contact on the anemometer.

4. Check the chronograph pen ink supply every week and top off if necessary.

5. An adjustment is provided on the bracket to enable the pen to be set in the right place.

6. The rain gauge (right hand) pen should track on the right hand line of the chart.

7. The anemometer (left hand) pen is more critical, since the main pen swings to zero and interlocking may occur. Clearance between the two pens at rest should be slightly over 1/16th inch.

Connection - Since failure to follow proper connections in wiring may cause permanent damage to the recorder, extreme care should be taken. The terminals are identified on both right and left side (viewing recorder from the front) and are as follows:

1. The leads from the tipping-bucket rain gauge are connected on the right side to two bakelite nuts.

2. The positive (+) black lead from the self-generating anemometer is connected to the terminal post at the bottom of the right side.

3. The leads from the Stewart anemometer are connected on the left hand side to two bakelite nuts.

4. The negative (-) white lead from the S.G. anemometer is connected to the terminal post at the bottom of the left side.

5. A red positive (+) and black negative (-) wire at the bottom of the left side panel connect to a 6V battery on the corresponding terminals. Here polarity is critical and care should be taken to make connections properly to avoid damage to vital parts of the instrument.

Care of inking system - At termination of the plot servicing, or should pen clogging occur, the inkwells and pen elements should be thoroughly cleaned with 50 or 70 percent alcohol. Do not damage the pen elements while removing them. Wash out inkwells, removing all dried ink. Use the rubber pen filler to force alcohol through the pen elements until clear. Let pen tips rest on absorbent paper towel or blotter until all fluid is drawn out of the pen elements. Clean and wipe any dried ink deposits that may occur around pen elements, chart drive, or case.

Care of 6.V. battery - The batteries currently in use to power the analog recorders are multiple ignition, six-volt batteries widely used as fencing batteries. The screw terminals are marked for polarity and these must correspond to the polarity indicated on the leads from the recorder. Normally this type of battery powers the recorder for a full season with little drop in voltage. As a precautionary measure the batteries should be tested by the servicing personnel every second week with the battery tester to guard against malfunction.

To test, remove the recorder leads from the battery terminals, clip the battery tester leads according to polarity onto the screw terminals. New batteries normally read at 10 (ten) on the scale. Any reading below 7 (seven) must be reported to the party chief. When testing, allow up to one minute or until the reading stabilizes.

Rain Gauges

The tipping-bucket rain gauge provides an instantaneous record of the rainfall. This instrument is wired to the right-hand chronograph pen of the operation recorder located on the meteorological tower. Beneath the funnel of the rain gauge is a see-saw tipping-bucket, which is calibrated to tip at one-hundredth (.01) of an inch of rain. When the bucket tips, it trips a magnetically-operated switch which causes the chronograph pen to make a lateral deflection. Rain in a given period is found by adding up the number of indentations and multiplying by .01 inches. As a secondary check a Glaisher's rain gauge with an 8 inch funnel is installed on the tower. The rainfall is funneled into a collection cup. The rain gauge is also equipped with an oil seal to impede evaporation.

Installation

The tipping-bucket rain gauge sits in one corner of meteorological platform. The rain gauge is levelled and held in place by three screws through the bottom of the rain gauge to a plywood base. The rain gauge is pre-wired and need only be attached to the analog recorder. This is accomplished by running the white lead wire beneath the tower platform to the recorder box. The wires are attached to the terminals marked "rain gauge". Polarity is not important in this case. The tipping-bucket should be checked by hand by moving it back and forth a few times and observing the trace and indicating "TEST" on chart roll. The bucket should be properly centered on the fulcrum and able to move freely. A few drops of light machine oil may be put on the bearings to facilitate movement.

The standard rain gauge is composed of a funnel, receiver, collecting cup and graduate cylinder. It sits on an arm levelled and extending over the tower railing. The rain gauge is fitted into a pre-cut hole. The collecting cup sits within a rim. The outer lip of the receiver is filled with a thin film of pale* oil to impede evaporation when the funnel is in place. Once a week the water is poured from the collecting cup into a graduate cylinder (8 inch), the total amount is entered in the water level book under the appropriate week and proper date. When spilling the water from the collecting cup to the graduate it should be done over the receiver to avoid loss of spillage. Finally the water in the receiver should be poured into the graduate and added to give total rainfall. The U-shaped tube should also be checked to make sure it is free from obstructions. Periodically the pale oil in the oil seal should be replenished.

---

* Carnea pale oil 21, used in oil drop traps.

Multiple Contact Anemometer

The Stewart Multiple Contact Anemometer is used in conjunction with a gust recording anemometer. Both instruments are joined to an operation recorder designed to record wind on a moving time-scaled chart and are located on the meteorological tower. The Multiple Contact Anemometer sits atop a galvanized television mast 35 feet above the ground surface and anchored to one of the tower legs. When properly wired the contact anemometer is set up to measure a mile of wind. The result is registered by the indentation of the left hand pen on the chart when viewed from the front.

Erection of the mast

Remove the galvanized coils of guy wire and acetate foam from the ends of the mast. The telescoping mast is anchored to one of the wooden tower legs and held in place at the bottom by an 8 inch steel nail driven through a pre-drilled hole. The nail should be driven until firm but not so far that it crimps the pipe. Care should be taken not to pierce the lead wire inside the pipe. The mast is also supported higher up by an arm extending out from the railing of the tower. This support arm has a notch cut to hold the mast but should not be nailed down until the mast is perpendicular from two directions. This is accomplished by using a carpenter's level. Now nail down the support arm. The mast is insulated from the arm by a layer of acetate foam. Then a galvanized band is nailed across the open end of the arm to hold the mast snugly. The ground strap should be connected to the ground rod.

Installation of multiple contact anemometer

The contact anemometer is composed of two parts: the anemometer box and the cup wheel. Adequate care should be taken in removing these parts from the protective case so that bending or damaging of either the cups or cup arms does not occur. The anemometer box is threaded with a 1/2" NPT (American National Taper Pipe Thread). This box is installed on a 1/2" pipe atop the mast being careful not to cross-thread the box. To inhibit corrosion and act as a seal, the pipe threads should be smeared with a petroleum jelly. Remove the anemometer box cover plate.

At the top of the mast the lead wires exit through a nipple in the 1/2" pipe. The wires are inserted into the hole at the lower left hand side of the anemometer box casing. These wires should be taped at the insertion point to prevent fraying. The two wires are joined to the colored contact screws in the lower left hand side. Polarity is not important in this instance.

Next install the cup wheel on the stainless steel spindle. To attach the cup wheel loosen the small set-screw in the hub of the wheel and slip the hub over the exposed end of the anemometer spindle so that the hole in the spindle will line up with the set-screw. Screw in the set-screw very slowly, jiggling the hub on the spindle just a little to make sure that alignment has been obtained. If the screw does not turn in easily back it out and recheck the alignment of the two holes.

Testing the contact

Thread the lead wires from the bottom of the mast into the white recorder box through the hole located on the right side of the box. Attach the lead wires to the black bakelite nuts on the left hand side of the operation recorder when viewed from the front. Immediately underneath are the red positive (+) and black negative (-) wires which must be connected to the proper terminals of the battery. This is very important.

Make sure the recorder is fully serviced as per instructions. To test the contact, gently spin the cup wheel until the revolving contact screw on the gear wipes firmly across the contact leaf spring. The outward deflection of the spring should be about 1/32". Adjustment of the spring is controlled by turning, in or out, the screw holding the spring. Avoid too much contact pressure or wear will become excessive and the spindle will "stick" in very light winds. Too little pressure, however, will increase the contact resistance and result in flickering and erratic action of the recorder pen and skipping of contacts at times. Check the trace to insure that the anemometer is working properly. The left hand chronograph pen would show a clear sharp lateral deflection indentation on the trace paper. Once the contact is firm replace the cover plate on the anemometer box.

Raising the mast

Uncoil the guy wires and prepare to raise the top section of the telescoping mast. Gently raise the mast while the lead wire is fed through the bottom at the same time. Secure each section until the mast is fully extended. Coil up the excess lead wire and tie it out of the way under the tower. Extend the guy wires at 120° angles and fasten them loosely to the permanently-fixed aluminum stakes. Be sure the galvanized wire does not contain any kinks. With one person stationed at the base of the mast and sighting up it, take up the slack by tightening all three turnbuckles until the mast is perfectly straight. The mast should not be bowed in the middle.

To run a final check:

1. Check the track of the pen on the chart to make sure the contact remains firm.

Testing the contact

Thread the lead wire from the bottom of the mast into the white recorder box through the hole located on the upper right side of the box. Service the operation recorder as outlined under the "Analog Recorder". Attach the lead wires to the terminals marked "gust recorder" being sure to attach the black positive (+) to the right-hand terminal and the white negative (-) to the left-hand terminal, (when the recorder is viewed from the front). Calibrations are carried out according to the directions under "Analog Recorder". Be sure the moving-coil measuring element (gust recorder pen) clears the left chronograph pen when it is at zero.

Raising the mast

Now the mast may be raised in a manner similar to the Multiple Contact Anemometer. The gust recorder mast may be permanently fixed. To run a final check:

1. Check the track of the gust recording pen.
2. Disconnect one lead wire of the "gust recorder" and observe if the pen zeroes.
3. Follow the outline of the "Analog Recorder" for zeroing.
4. The chronograph pen should clear the gust recording pen at zero.
5. Replace the lead wire.
6. Check the recorder time (Central Standard Time) against a watch and correct if necessary.
7. Write down the plot, time and initial it.
8. Lock the recorder shelter.

Hygrothermograph - Short and Mason

This unit is spring driven and records both the humidity and temperature on the same chart.

Chart cylinder

The cylinder mechanism is similar to the recording pyrheliometer. The mechanism is housed in the drum but all precautions in handling

apply, namely; life the cylinder straight up, when replacing, lower gently until drive gears mesh.

Winding

Mechanism is wound with a key. Do not overwind. Stop when solid resistance of the mainspring is felt.

Mounting the chart

Wrap the chart around the cylinder with time reading left to right making sure that the lower edge of the chart rests squarely on the flange at the bottom of the cylinder. While holding the chart snugly in place (some drums are provided with pin retainers) slip the spring retaining clip down into the slot of the drum and the access in the upper rim. Replace the key, then the lid on the drum.

Servicing

In servicing this unit make sure the following steps have been checked:

1. Remove and replace chart.
2. Write plot - date - time (C.S.T.) and initials on new chart at start.
3. Wind hygrothermograph, replace key and thumb nut, then lid.
4. On front of chart removed, write the time, and the maximum, minimum and current temperatures from the Max.-Min. thermometer and initial.

Inking the pens

Actuate pen lifter to remove pens from chart face. With applicator ink the pens, red for relative humidity and green or blue for temperature. Do not overload, as ink is hygroscopic. Check previous pen traces, if faint or pen skips are evident replace ink or correct fault, replacing nib if necessary. During high humidity periods dilution may cause a faint trace. If this occurs remove ink from pen with kleenex, clean any sedimentation and replace with fresh ink supply then recheck trace. Avoid tilting instrument when replacing inside the Stevenson screen since pens may stick to glass face.

Maintenance

Use water and a clean chamois leather for cleaning glass and an oily rag for cleaning and wiping over case. Wash away spilled ink inside case and clean pens with alcohol. Check to see that pen slits are uniform. Lubricate sparingly.

Hygrothermograph - Fuess 79r

These new units were installed at each plot in 1965. The 79r records both temperature and relative humidity of the air on separate charts. Instructions for the installation, operation and servicing are similar to the Short-Mason hygrothermographs. Because of the dual purpose of this machine, additional working instructions are outlined below.

Installation and operation

1. The case opening lever is located on the left side, under the base plate.

2. The clock mechanism is key wound from the top. Rotate drum sharply back and forth if movement fails to start immediately after winding.

3. Drum, and chart removal, and replacement is similar to the Short & Mason.

4. In transporting this unit the tension on the hair bundles should be slackened to avoid damage. A small retention lever on the side wall of the casing hooks into the pen arm for this purpose.

Regulating humidity measuring mechanism

In the spring before setting the instrument out in each plot the hygrograph should be checked for accuracy and adjusted accordingly in the following manner.

1. A saturated moistening cloth supplied with each instrument is draped over the protective grille basket so as to close all openings.

2. In approximately 30 minutes, the air inside should be completely saturated and the pen should indicate 96% of relative humidity. The adjustment can be hastened by gently tapping the unit.

3. If the pen is above or below 96% this can be corrected by the fine adjustment screw located on the underside of the hair bundles holding plate. The screw can be reached through a hole in the base bored for this purpose.

4. For a high degree of accuracy a Bendix psychrometer is used in testing. Comparisons should be carried out in a warm room where temperature and humidity remain constant otherwise differences may occur between the instruments owing to the fact that the hygrograph responds more slowly to a change than the psychrometer. Periodic checks should be carried out with the psychrometer in the field. On these occasions the readings on the psychrometer should be compared to the hygrothermographs. Where discrepancies are found the hygrothermographs should be corrected to correspond with the psychrometer and the temperature and humidity readings at that time entered on the chart.

Maintenance

Wash away any spilled ink inside the case and clean pens with alcohol. Check to see that pens are in good condition. Lubricate sparingly.

Maximum - Minimum Thermometers

This self-registering thermometer contains mercury in a connecting 'U'-tube with indices in each column indicating temperatures (max.-min.) registered by either mercury column. The left-hand bore registers the minimum index and the right-hand bore is the maximum index. With temperature fluctuation, the maximum index remains at the highest graduation indicated by the increase and the minimum index remains at the lowest graduation indicated during a temperature decrease. Readings are taken from the bottom of the indices.

Procedure

Readings are taken weekly after servicing both hygrothermographs. These three units are housed in a Stevenson screen located at each plot. The max.-min. reading should be recorded on the front of the chart removed from the hygrothermograph and in the field record book for water level readings.

Resetting indices

Place the magnet in a horizontal position across the 'U'-tube and draw downward slowly until the indices come to rest gently on the tops

of the mercury columns. During transit or from severe vibration the mercury column may separate or cause the indices to slip down into the mercury. To reunite columns, grasp thermometer at top and swing downwards forcefully until reunited. To release indices use the magnet to draw them out of the mercury.

Stevenson Screens

Each plot has a meteorological screen to house the hygrothermographs and the max.-min. thermometer. In setting up these screens, sink the stand into the bog until the floor of the screen is four feet above the ground. Check that the screen is level: on installation, and on yearly basis from then on.

Recording Pyrheliometer

This unit is a self-energized instrument for recording solar heat energy.

Chart cylinder

The chart cylinder has a hollow central support that forms the bearing on which it rotates. When the mechanism is to be wound or the chart changed, the cylinder is removed by unscrewing the thumb nut at the top and lifting the cylinder straight up.

When the chart cylinder is replaced, lower gently, straight down until the drive gears mesh into the operating position. Do not drop or force cylinder into place. Simply rotate cylinder slightly until gears contact.

Winding

Once the chart cylinder is removed the drive mechanism is wound by operating the winding lever back and forth. Do not overwind. Stop winding as soon as solid resistance of the mainspring is felt. The spring can be wound with 24 ninety degree strokes of the lever. When completed, push lever back towards center spindle to lock to prevent interfering with the cylinder.

Mounting the chart

To apply chart, wrap around the cylinder with time reading left to right and make sure that the lower edge of the chart rests squarely

on the flange at the bottom of the cylinder. While holding the chart snugly in place slip the spring retaining clip down into the slot in the retaining flange of the drum and the recess in the upper rim. When changing charts, remove the spring retainer clip with caution since once clear of slot it may spring clear from your grasp and drop in the bog.

Setting the time

To set recorder to time rotate the cylinder clockwise until desired time line is a little to the left of the pen, then counterclockwise to proper time setting. This removes any effect of backlash in the drive gearing.

Maintenance

The glass dome must be kept clean for accurate results and should be wiped with a soft clean cloth periodically. Do not touch the bimetal strips.

Procedure

In servicing this instrument make sure the following steps have been checked:

1. Remove and replace chart.
2. Write plot, date, time (C.S.T.) on new chart at top left.
3. Wind pyrheliometer, replace thumb nut, check ink supply and trace.
4. On end of chart removed - write time and date of removal.

Inking the pen

Remove stopper from bottle and withdraw applicator smartly so that ink clings. Touch loaded applicator to open end of the pen. Do not overload as ink is hygroscopic. During high humidity periods dilution may cause a faint trace. If this occurs remove ink from pen with blotting paper (kleenex) and replace with fresh supply and check trace.

Laboratory procedure

At the start of each chart, the plot, date and starting time should be noted. Check the starting time for accuracy with the preceeding chart.

At the end of each chart the date and time of removal should be checked with the trace. The trace should be checked for zero as well. The trace should follow the zero line during the early morning and late evening hours, if not, a line should be drawn parallel to the zero line at the lowest point of the trace. This line becomes the "zero" line.

The next step is to pick out the daily maximum radiation reading. Vertically the chart is marked off in unit divisions up to an amplitude of three. From left to right the chart is marked off in two hour intervals and twenty-four hour days running from Monday through to the following Monday. The days of the week will not coincide with the dates of the calendar usually, thus the date in the upper left hand corner should be followed. At the beginning and ending of each weekly chart, the maximum reading for the day may be found on the end of the preceeding chart. This fact also holds true for the area which will be measured later. In some cases if the machine is not zeroed a correction factor may be added or subtracted to compensate for the zeroing. Once the true reading is obtained, it is entered on the pyrheliometer record sheet on the proper day and under the heading "MAXIMUM". This step should be carried out for all the plots before proceeding with the area measurement.

The area measurement is obtained by using a chart magnifier and an Allbrit Compensating Planimeter. The chart magnifier consists of a fan, a light bulb for image projection, a plexiglass chart rack, a Zeiss press camera and a ground glass plate. The image is projected from the chart rack through the camera to the surface of the ground glass plate marked off similar to the pyrheliometer chart. The twelve o'clock line in the twenty-four hour period should be centred over the zero. The midnight (0000) and the midnight (2400) should line up with the vertical lines on the ground glass surface. If not centred, the Zeiss press camera has three knurled knobs for adjusting the image; a large knob for focusing and two small knobs for horizontal and vertical alignment. Where the trace line is not clear, move the tracer point of the planimeter along the intercept of the two hour interval.

Steps

The following steps should be followed:

1. Plug in the light cord and the fan.
2. Remove the plexiglass chart rack from the bottom.
3. Insert the pyrheliometer chart in the rack upside down and backwards.
4. Close the chart cover plate and insert the rack in the chart track from the left hand side.

5. Slide the rack in until the first day appears on the ground glass and the noon position lines up with the black "0" mark.

6. Read the planimeter instruction booklet.

7. Set the planimeter at "20" on the graduated scale.

8. Assemble the planimeter and place the tracer point in the centre of the area. The pole arm should be placed at right angles to the tracer arm. Do not allow measuring wheel to roll on ground glass surface. Provide a smooth (paper) surface.

9. Move the tracer arm through the area to make sure it is within the range of the instrument.

10. Position the pole arm.

11. Move the tracer point to midnight (0000) and set the small revolving wheels to zero.

12. Follow the trace line until it comes to midnight (2400).

13. Follow the "zero" line back to the starting point.

14. Write down the reading obtained under the heading "AREA".

The reading of the planimeter consists of four figures. The first figure is obtained from the counting dial. This figure is generally zero. The partial revolutions are given on the measuring wheel. The figures and subdivisions giving tenths and hundredths of a revolution and finally the vernier reading to thousandths. This figure is entered on the pyrheliometer record sheet under the heading "area".

Once all the sheets have been done for the six sample plots, the area readings are converted to radiation readings. This is accomplished by multiplying each area measurement by the conversion factor of 1.65. The result is entered under the heading "CONVERSION" and expressed in Langley's units. The results are now ready to enter on the data card 02 under the columns twenty-nine to thirty-four.

Tensiometers

These measurement devices were introduced in each plot in mid-1963 in an attempt to obtain data that can be used to determine soil-moisture conditions at different depths during that period when larvae are spinning cocoons.

Care and servicing

In late June prior to setting up, the tensiometers are subjected to a conditioning period, then calibrated. The neoprene stopper is removed, the tube carefully filled with distilled water, so as not to trap air in the instrument, until it appears in the top of the visual tube. Press cork into place slowly, allowing several seconds in the process, to permit the extra water, under pressure, to escape through the pores of the ceramic cup. If cork is jammed in carelessly it may pop out as well as damage the gauge by the force of the extra pressure from within.

Pour an ounce of water into the small plastic bag, slip over the ceramic bulb and using elastic bands close the bag snugly over the copper tube to prevent any moisture loss. Set the tensiometers in racks and allow to stand for several hours until moisture conditions are stabilized. Recalibrate to "0" on the gauge by unscrewing the face plate counter clockwise and adjusting the set screw on the gauge face.

Method

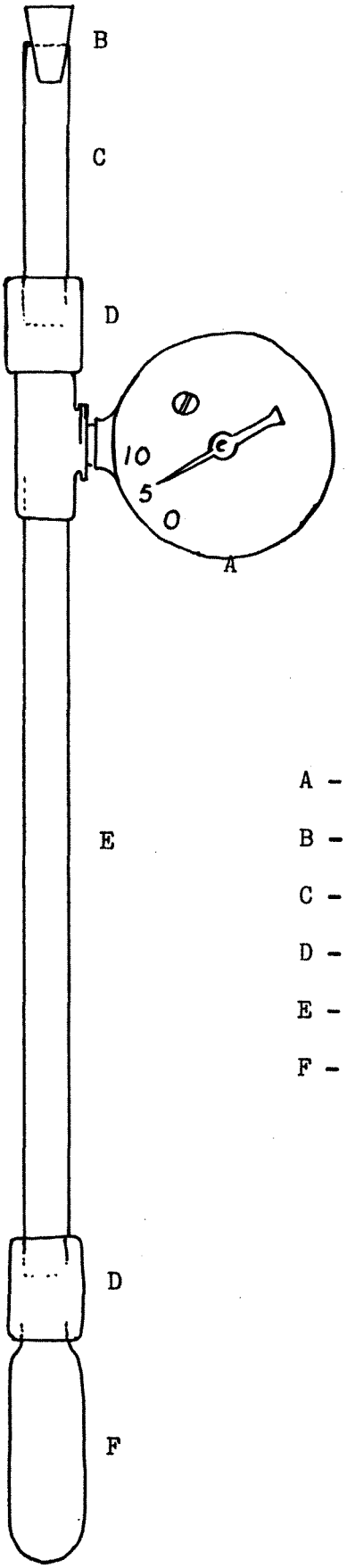
When transporting to the plots, the tensiometers are carefully packed 3 to a crate taking care that there is sufficient water in the plastic bags around the bulbs. At the plot, punch a 6, 12, 18 inch hole using a standard water level pipe with a sharp cutting edge. Carefully unpack devices, remove plastic bags at bulb and sink bulbs to respective depths. Check gauge, it may be necessary to recalibrate due to shocks in transporting.

Readings are then taken weekly as with the water level readings through the season and recorded in the field books.

Maintenance

In late August the tensiometers are removed. Do not attempt to pull the instrument from the ground without first digging the soil away. The units are then drained thoroughly. Wash ceramic cup with clean water to remove dirt and prevent pores from becoming clogged.

TENSIOMETER



A - Vacuum gauge with recalibrator

B - Neoprene stopper

C - Pyrex glass tube

D - Neoprene hose

E - Copper tube

F - Ceramic bulb

Eppley 180° Pyranometer

This instrument measures the total sun and sky radiation received on a horizontal surface.

Description of pyranometer

The pyranometer consists of a thermopile mounted under a thin flat concentric silver ring receivers, (1 1/8 inch in diameter) in thermal contact with but electrically insulated from them. The whole radiation-receiving unit is hermetically sealed in a 3-inch blown glass bulb.

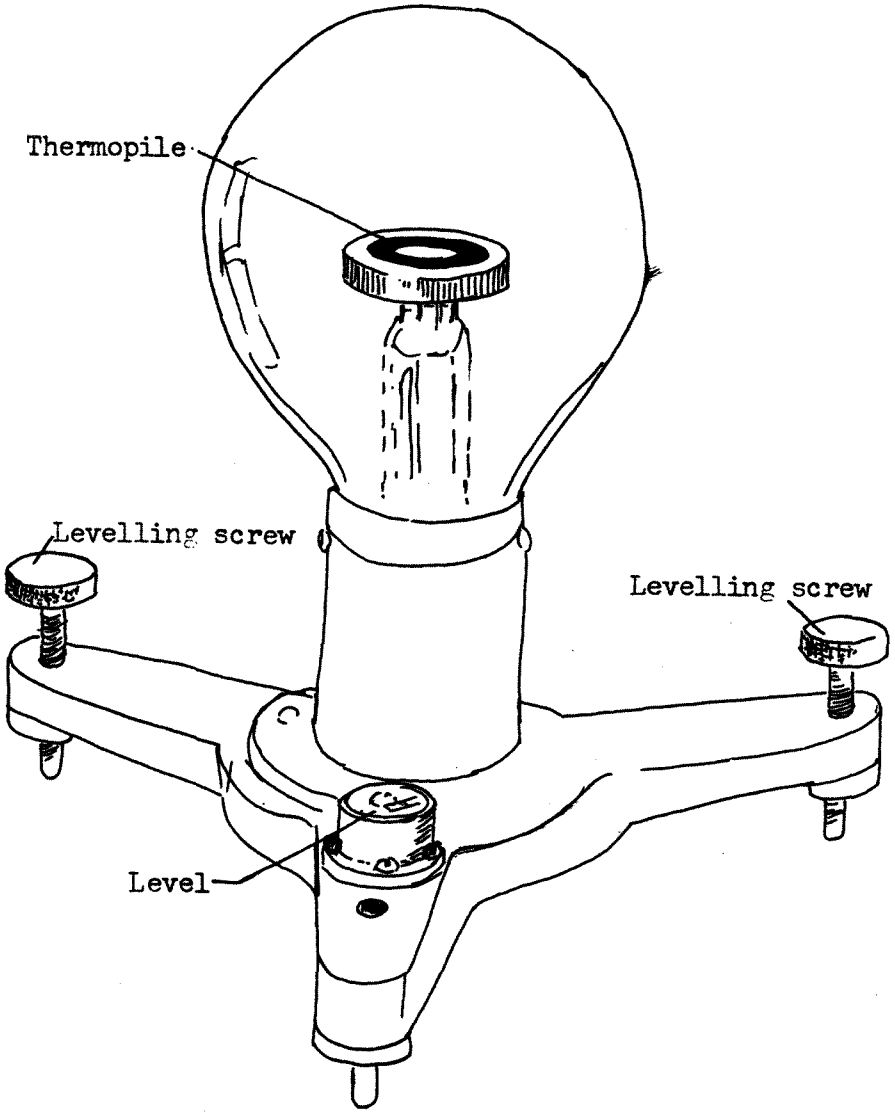
Exposure of the pyranometer

The site for the pyranometer should be free from any significant obstructions above the plane of the sensing element and, at the same time, should be readily accessible. If it is impracticable to obtain such an exposure, the site selected must be as free from obstructions either artificial or natural, especially from east-northeast, through south in the Northern Hemisphere. If practicable, the instrument should be located so that (a) a shadow will not be cast on it at any time (masts, trees, etc.); (b) it is not close to light-colored objects likely to reflect sunlight onto it (c) not exposed to artificial radiation sources.

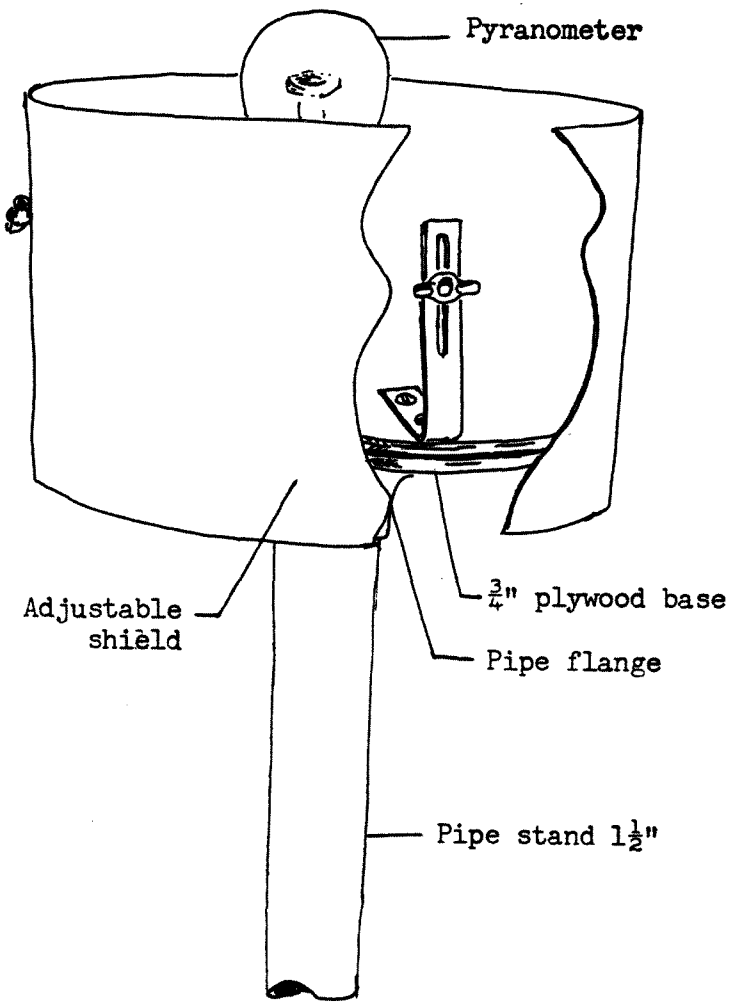
Installation

The pyranometer should be securely attached to a rigid mounting stand, horizontal to the top surface used, with wood screws provided in one of the tripod legs. Extreme precautions should be taken to avoid subjecting the instrument to mechanical shocks during installation and proceed as follows. First, orient the pyranometer so that the retaining screw is located approximately south (in the N. Hemisphere) of the receiving surface. The pyranometer should then be secured lightly with this screw. Level the instrument with the aid of the levelling screws and the circular spirit level mounted on the tripod, and tighten the retaining screw taking care that the setting is not disturbed. The stand should be sufficiently rigid so that severe shocks to the instrument do not occur during the periods of exposure, or the horizontal position of the receiving surface change, especially during high winds.

The cable employed to connect the pyranometer with its recorder should be twin conductor and waterproofed. This cable should be firmly secured to the pyranometer mounting stand to minimize breakages and intermittent contacts in windy weather. Wherever possible, the cable



Eppley 180° Pyranometer



Field installation

should be run either along or under the ground to the recorder, if the latter is to be located at some distance. High overhead connections should be avoided, particularly in areas of severe thunderstorm activity.

After identification of circuit polarity (the short positive (+) pyranometer lead is marked) the other extremity of the cable should be connected to the recorder according to instructions.

Maintenance

Pyranometers in continuous operation should be inspected at least once per day. At these inspections, the glass bulb should be wiped clean and dry with tissue paper or with a fine muslin tissue. At places situated in desert or very arid regions, this wiping of the envelope should be carried out very gently, preferably after blowing off most of the loose dust or after wetting it a little, in order to prevent scratching of the glass surface. Such abrasive action can alter appreciably the original transmission properties of the glass (and hence the pyranometer calibration). If frozen snow, glazed frost, hoar frost or rime is present, an attempt should be made to remove the deposit at least temporarily. The circular spirit level of the pyranometer should be inspected at regular intervals.

Limpet Logger

This instrument converts analogue input into digital form for recording. Two of these units were installed for field trials at the Rennie life-table plot in 1966.

Operation and Maintenance

1. Component Units - The recorders include the following component units.

   Magnetic tape deck
   Analogue to digital converter
   Sequence controller
   Clock mechanism
   Battery unit
   Battery voltage regulator
   External sockets
   Aluminum water-tight case, two straps
   Silica gel pack
   Ten channel input selector
   Temperature measurement unit

2. External connections - These consist of one ten-way and one twenty-four-way plug arrangement. Once fitted to the unit these are waterproof. In order to prevent water seeping into the leads connected to the plug, the following precautions should be taken.

    1. The individual leads must pass through the hole in the gasket and must be at least 1 mm in diameter.

    2. Tighten all connections.

    3. Use silicone grease on threads.

3. Battery - Batteries are fitted in the battery container (total of 13.5 volts) and a 1 1/2 volt cell is fitted in the clock unit. Check battery connections.

4. Clock - If any adjustments are necessary the following precautions should be observed:

    1. When setting, the hands must be moved in a clockwise direction.

    2. Check to see that the brushes are making contact with the metal on the clock dial when the instrument is in operating position.

    3. Timing adjustment lever is found on the back of the clock.

    4. The clock face must be free from dirt and may be cleaned with methylated spirits.

5. Tape deck - Under normal conditions and with the unit sealed except for periodic examination the tape deck requires no maintenance.

6. Tape Reel and Cassette - A high capacity cassette holds a reel of magnetic tape and a take-up spool. Tape length is 900 feet. When replacing a cassette proceed as follows:

    1. Check cassette for cracks, manually wind leader onto take-up spool by depressing release bar at back of cassette.

    2. Insert cassette on tape deck with full reel on left hand side.

    3. Check that new labels are on the cassette so that start and stop information can be written on them. When entering times, the end position of the contacts not the hands indicate time started or stopped.

    4. Set switch to ON position.

7. Sealing Ring - The sealing ring is a silicone rubber O ring which can be removed without difficulty from the sealing channel. When replacing the lid care must be taken to prevent damage to the walls of the channel or the ring. See that no dirt or other objects are on the ring when sealing the unit.

8. Final checks - Before sealing the Logger and securing the metal straps check to ensure that:

   1. The cassette is fitted correctly.

   2. That the switch is set in the ON position.

TRANSCRIBING DATA

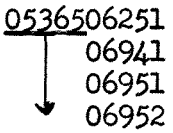
Life table data and meteorological records are entered on standard 80 column sheets (Form A332) and sent to Ottawa to be punched onto cards. In transferring information to data sheets it is essential to protect the sheets from smudging, wrinkling or any other factors that may reduce legibility. The entries are made on every second line so that corrections may be made by striking out the wrong figures and inserting the corrections immediately above the figures in error. Legibility increases the speed and accuracy of keypunching and verifying.

Uniformity is also essential in the presentation and identification of data sheets. The data sheets should be identified in the top right hand corner with the plot name and number, definition of card type (i.e. oil funnels, wind gusts etc.) year, and page number.

When indicating repetitive rows of information, the use of horizontal arrows is permitted, provided that the character which is repeated is clearly indicated in the first position of the field in which it occurs and that no other digit occurs within this field of repeated digits. For example:

	0000000076
can be written	0———→76
but	0000020076
must be written	0——→20076

Repetition of data which occurs in the same rows on a number of consecutive cards may be indicated by a vertical arrow. A line should be drawn under the repeated field by a downward pointing arrow, thus:



If carried onto subsequent sheets this complete numerical information should be given for the first line of each sheet.

Definition of a row or field are as follows:

A row a data is any set of individual readings or figures which refer to a specific observation or observational unit. It may consist of one numerical value only. All data on one row will be punched on a single card.

A field is a group of figures which make up a single numerical value. Fields should be called one digit, two digit etc. or one column, two column etc. If a decimal point is to be punched then it must be counted as part of the field.

In addition to uniformity the following points should be adhered to when entering data:

a) Letters and numerals should be written as clearly as possible, using the following convention for these letters and figures.

Letter O written as	∅
Figure zero written as	0
Letter I written as	I
Figure 1 written as	1
Letter Z written as	Z

b) Zeros to be punched must be written on the data sheet. A space in the written data will be left blank on the card.

c) Blanks and zeros are synonymous.

d) In our data coding, missing data caused by machine malfunction is indicated by a minus sign. The program is then arranged to pick this up and act accordingly.

Larch Sawfly Project Code Cards

Code for card, date, plot and points to watch when entering on data sheets are as follows:

Card 01 - Daily air temperature and relative humidity

Both readings are taken at 2 hour intervals at the intersects from the Fuess charts with adjustments, if any and checked against the Short-Mason charts. Enter chart date in pencil in right hand remarks column.

Card 02 - Daily radiation and precipitation

Radiation procedures and conversion are explained under "Recording Pyrheliometer". Enter chart date in right hand remarks column to simplify checking.

Card 03 - Daily wind mileage and gust velocity

The maximum gust velocity and total wind mileage for 2-hour intervals are coded directly from the recorder chart. Indicate on the chart margin total mileage for the 2-hour interval and gust velocity at the peak entered in the data sheet.

Card 04 - Precipitation in 10-minute periods.

This is coded directly from the recorder chart. Indicate on chart counts entered on data sheet, time division etc. to facilitate checking.

Card 05 - Gust velocity in 10-minute periods

Similar to card 03, except that maximum gust velocity and total wind mileage is recorded for each 10-minute interval during the 2-hour period.

Card 06 - Oil funnel collections.

See "Examination of larvae at Winnipeg laboratory" and handling drops with Holocremnus parasitism at Pine Falls and Riverton.

Card 07 - Colony collections

Procedures for Pine Falls and Riverton Holocremnus parasitism similar to card 06. Be sure to enter whether mass collection (W) or crown class if so designated on the enclosed tag.

Card 08 - Larval drop collections

Card 09 - Parameter cards for eggs, larval and adult periods

Card 10 - Female reproductive capacity

Code cards and descriptions are as follows:

Larch Sawfly Project
Code for card, plot, date
for all data cards

Column	Entry	Definition
1, 2		Card Type
	01	Daily air temperature and R.H.
	02	Daily radiation and precipitation
	03	Daily wind mileage and gust velocity
	04	Precipitation in 10-min. periods
	05	Gust velocity in 10-min. periods
	06	Oil funnel collections
	07	Colony collections
	08	Larval drop collections
	09	Parameter cards for egg-larval-adult periods
	10	Female reproductive capacity
3		Plot
	1	Rennie
	2	Telford
	3	Agassiz
	4	Pine Falls
	5	Riverton
	6	Darwin
4,5		Year (55,----------60, etc.)
6, 7, 8		Day (Day 1 = March 1)
	001	March 1
	032	April 1
	062	May 1
	093	June 1
	123	July 1
	154	August 1
	185	September 1

Card 01

Larch Sawfly Project
Temperature and Humidity

Column	Entry	Description
1, 2	01	Daily air temperature and relative humidity
3 - 8		Plot and date identification
11, 12	0200	Air temperature at 2 hr. intervals
13, 14	0400	

33, 34	2400	
35, 36		Daily Max. Air temperature
37, 38		Daily Minimum Air temperature
41, 42	0200	R. H. (%) at 2 hr. intervals (readings above 99% recorded as 99
43, 44	0400	

63, 64	2400	
65, 66		Daily maximum R.H.
67, 68		Daily minimum R.H.

Card 02

Larch Sawfly Project
Radiation and Daily Precipitation

Column	Entry	Description
1, 2	02	Daily radiation and precipitation
3 - 8		Plot and date identification
11, 12	0600)	Radiation reading at 2 hr.
13, 14	0800)	intersects
15, 16	1000)	
17, 18	1200)	
19, 20	1400)	
21, 22	1600)	
23, 24	1800)	
25, 26	2000)	
27, 28	2200)	
29, 30		Daily maximum radiation reading
31, 32, 33		Total area under daily curve
36, 37, 38	0200)	Total precipitation during 2 hr.
39, 40, 41	0400)	intervals ending on given hour
42, 43, 44	0600)	
45, 46, 47	0800)	
48, 49, 50	1000)	
_____	)	
_____	)	
_____	)	
_____	)	
69, 70, 71	2400)	
72, 73	Max. pption.	intensity in any 5-min. period
74, 75	Max. pption.	intensity in any 10-min. period

Note: If a period straddles midnight, move to one date only.

Card 03

Larch Sawfly Project
Wind

Column	Entry	Description
1, 2	03	Daily wind mileage and gust velocity
3 - 8		Plot and date identification
11, 12	0200)	
13, 14	0400)	Maximum gust velocity during
15, 16	0600)	
17, 18	0800)	each 2 hr. interval
19, 20	1000)	
21, 22	1200)	
23, 24	1400)	
25, 26	1600)	
27, 28	1800)	
29, 30	2000)	
31, 32	2200)	
33, 34	2400)	
38, 39, 40	0200)	
41, 42, 43	0400)	
44, 45, 46	0600)	
47, 48, 49	0800)	Total wind mileage during
50, 51, 52	1000)	
53, 54, 55	1200)	each 2 hr. period
56, 57, 58	1400)	
59, 60, 61	1600)	
62, 63, 64	1800)	
65, 66, 67	2000)	
68, 69, 70	2200)	
71, 72, 73	2400)	
74, 75, 76		Total daily wind mileage (Left blank for machine to compute and add)

Card 04

Larch Sawfly Project
Maximum Precipitation

Column	Entry	Definition
1, 2	04	Precipitation for 10 min. intervals within 2 hr. periods selected for rainfall (.25" rain or more in 10 minutes, only from June 1 to Aug. 31)
3 - 8		Plot and date identification
11-12		Hour (2 hr. period beginning at given time)
	00	0001 - 0200
	02	0201 - 0400
	04	0401 - 0600
	06	0601 - 0800
	08	0801 - 1000
	10	1001 - 1200
	12	1201 - 1400
	14	1401 - 1600
	16	1601 - 1800
	18	1801 - 2000
	20	2001 - 2200
	22	2201 - 2400
13, 36		Precipitation during 10-min. periods
13, 14		01 - 10 min.
15, 16		11 - 20 min.
17, 18		21 - 30 min.
19, 20		31 - 40 min.
21, 22		41 - 50 min.
23, 24		51 - 60 min.
25, 26		61 - 70 min.
27, 28		71 - 80 min.
29, 30		81 - 90 min.
31, 32		91 - 100 min.
33, 34		101 - 110 min.
35, 36		111 - 120 min.
39, 40		Max. intensity in any 5-min. intervals
41, 42		Max. intensity in any 10-min. intervals
43, 44		Max. intensity in any 15-min. intervals
45, 46, 47		Max. intensity in any 30-min. intervals

Note: Intervals may extend beyond the limits of the 2-hour period, as long as more than 1/2 the rainfall lies within this 2-hour period.

Card 05

Larch Sawfly Project
Maximum Wind Gusts

Column	Entry	Definition
1, 2	05	Wind mileage and maximum gust velocity for 10-min. intervals within 2 hr. periods selected for high winds (21 m.p.h. or over)
3 - 8		Plot and date identification
11, 12		Hour (2-hr. period beginning at given time)
	00	0001 - 0200
	02	0201 - 0400
	04	0401 - 0600
	06	0601 - 0800
	08	0801 - 1000
	10	1001 - 1200
	12	1201 - 1400
	14	1401 - 1600
	16	1601 - 1800
	18	1801 - 2000
	20	2001 - 2200
	22	2201 - 2400
13-36		Maximum gust velocity during 10-min. periods within 2-hr. intervals
13, 14		01 - 10 min.
15, 16		11 - 20 min.
17, 18		21 - 30 min.
19, 20		31 - 40 min.
21, 22		41 - 50 min.
23, 24		51 - 60 min.
25, 26		61 - 70 min.
27, 28		71 - 80 min.
29, 30		81 - 90 min.
31, 32		91 - 100 min.
33, 34		101 - 110 min.
35, 36		111 - 120 min.
39-62		Total wind mileage during 10-min. periods
39, 40		01 - 10 min.
41, 42		11 - 20 min.
43, 44		21 - 30 min.
45, 46		31 - 40 min.
47, 48		41 - 50 min.
49, 50		51 - 60 min.
51, 52		61 - 70 min.
53, 54		71 - 80 min.
55, 56		81 - 90 min.
57, 58		91 - 100 min.
59, 60		101 - 110 min.
61, 62		111 - 120 min.

Card 06

Larch Sawfly Project
Oil Funnel Collections

Column	Entry	Definition
1, 2	06	Oil funnel collections
3 - 8		Plot and year identification
9		Instar
	1	I
	2	II
	3	III
	4	IV
	5	V (early)
	6	V (mature)
	7	V (parasitized - Holocremnus)
10		Condition
	1	healthy
	2	diseased
	3	killed by predator (shrivelled, decapitated or multilated)
11, 12, 13		Number of larvae
15-80		Record of Bessa attacks on 9 larvae
15 22 29 36 43 50 57 64 71		Number of unhatched eggs (u)
16 23 30 37 44 51 58 65 72		Number of hatched eggs (h)
17 24 31 38 45 52 59 66 73		Number of hatched eggs with scar (hs)
18 25 32 39 46 53 60 67 74		Number of hatched eggs with scar and maggot (hsm)
19 26 33 40 47 54 61 68 75		Number of scars (s)
20 27 34 41 48 55 62 69 76		Number of scars with maggots (sm)

Card 08

Larch Sawfly Project
Larval Drop Funnel Cocoon Collections

Column	Entry	Definition
1, 2	08	Larval Drop Funnel Collections
3		Plot
4, 5		Year (cocoons collected)
6-8		Collection Number
	001-100	Sampling unit position fixed
	101-200	Sampling unit position relocated annually.
9		Sampling unit position in relation to tree crowns:
	0	not recorded
	1	completely under crown
	2	partially under crown
	3	centre of funnel __ ft. of crown edge
	4	centre of funnel __ ft. of crown edge
10-12		Distance (nearest inch) from bottom of box to plot datum (+ or - to the)
13		Comments on sorting
	0	none
	1	ants nest in sampling unit
	2	Carabid in sampling unit
	3	Staphalinid in sampling unit
15-45		Normal cocoons
15-28		(fall mortality)
29-45		(rearing results)
15-17		Number of cocoons
18-19		Number of cocoons with B. harveyi emergence holes.
20, 21		Number killed by insect predators
22		No. killed by fungi
23		No. dead with dead B. harveyi inside
24, 25		No. of unknown dead
26-28		No. sound cocoons remaining
29		No. Ctenochira emerged
30		No. of cocoons killed by fungi
31		No. of cocoons containing dead B. harveyi
32, 33		No. of unknown dead
34		No. of holdovers

Card 10

Larch Sawfly Project
Adult Size and Reproductive Capacity

Column	Entry	Definition
1, 2	10	Adult size and reproductive capacity.
3-8		Plot, year, day.
11-13		Adult No.
15		Days from emergence to weighing.
17-20		Adult weight (Mg. x 10).
22-25		Interocular distance (mm. x 100)
28-31		No. mature oocytes
33-35		No. near-mature oocytes
37-39		No. large immature oocytes
49-51		Total oocytes
53-60		Comments
53	0 1 2 3 4	Normal condition of fat body large fat body as in teneral adult
55	0	Normal hind gut-colorless and empty
	1	containing green meconial mass
61-75		Per cent distribution of oocyte categories
61-64		Per cent mature
66-69		Per cent near-mature
71-74		Per cent large immature

LARCH SAWFLY PROJECT

Date Codes for All Data Cards

Date	Code	Date	Code	Date	Code	Date	Code	Date	Code
May 20	081	June 14	106	July 9	131	Aug. 3	156	Aug. 28	181
21	082	15	107	10	132	4	157	29	182
22	083	16	108	11	133	5	158	30	183
23	084	17	109	12	134	6	159	31	184
24	085	18	110	13	135	7	160	Sept. 1	185
25	086	19	111	14	136	8	161	2	186
26	087	20	112	15	137	9	162	3	187
27	088	21	113	16	138	10	163	4	188
28	089	22	114	17	139	11	164	5	189
29	090	23	115	18	140	12	165	6	190
30	091	24	116	19	141	13	166	7	191
31	092	25	117	20	142	14	167	8	192
June 1	093	26	118	21	143	15	168	9	193
2	094	27	119	22	144	16	169	10	194
3	095	28	120	23	145	17	170	11	195
4	096	29	121	24	146	18	171	12	196
5	097	June 30	122	25	147	19	172	13	197
6	098	July 1	123	26	148	20	173	14	198
7	099	2	124	27	149	21	174	15	199
8	100	3	125	28	150	22	175	16	200
9	101	4	126	29	151	23	176	17	201
10	102	5	127	30	152	24	177	18	202
11	103	6	128	July 31	153	25	178	19	203
12	104	7	129	Aug. 1	154	26	179	20	204
13	105	8	130	Aug. 2	155	27	180	Sept.21	205