An Observational Analysis and Recommendations

Concerning Streamflow and Water Table Encounters

Along the South-east Corner of the

Hopkins Forest Loop Trail

submitted by Keely Maxwell

as an independent project

for Environmental Studies 102

May 11, 1990

"The job of recreational engineering is not one of building trails into lovely country, but of building receptivity into the yet unloving human mind."

-- Aldo Leopold

"Wilderness to the people of America is a spiritual necessity, an antidote to modern life, a means of regaining serenity and equilibrium."

-- Sigurd Olson

I. **ABSTRACT:**

For my independent project I undertook to analyze a trail. More specifically, I investigated the erosion and appearances of water in the SW corner of the Hopkins Forest loop trail, between where it twice crosses the middle branch of Birch Brook (see map). The loop trail has moderate use by hikers, runners, and cross-country skiers.

In my investigation, I mapped out the trail, noting where the water was located, speculated from looking at the water patterns and surrounding hillside as to from where the water came--whether it was an outcropping of the water table or part of a stream basin-- and measured water flow if possible. Using my field research data, information I had gathered from outside sources, and previous knowledge about trail construction, I made recommendations as to how the eroding trail could be reconstructed so as both to satisfy trail users and to minimize disturbance of the trail and surrounding areas.

II. ~~INTRODUCTION:~~

A. GENERAL:

In our society, one of our main goals is to progress, to get places. For this purpose we have built all sorts of roads and paths in order to communicate with one another and get somewhere, even though we may not be sure to where. Every once in a while, however, we need, as Sigurd Olson writes, an "antidote to modern life", namely, a journey into the outdoors or wilderness. When we venture into the woods, the paths we take are not primarily for the purpose of getting us places, but of introducing us to what we usually do not see by the wayside.

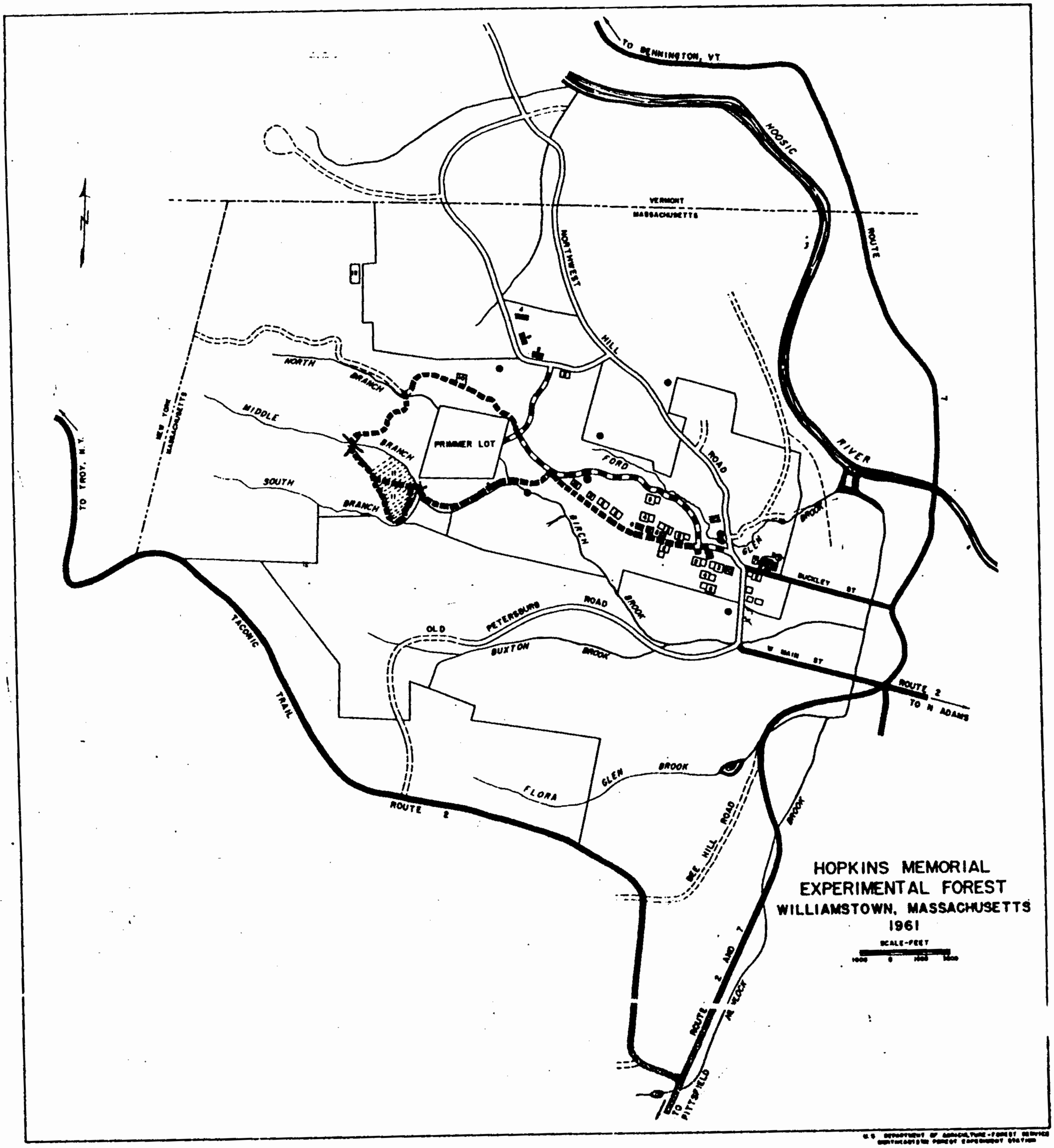
In order to have a good excursion into the outdoors, we need good trails to travel upon. There are several reasons for maintaining good pathways. First, having a specific trail minimalizes the damage a traveller can do to the natural environment. It is better to concentrate human damage than to (once you get to some minimum level of use!) let people hike wherever they want, thereby destroying more natural soil, vegetation and wildlife. Second, a well-made trail invites people to travel upon it, so they do not get lost. Third, people should not have to constantly worry about whether they are going to lose their footing in mud or slide down a cliff. Not only do trail makers have to worry about the actual safety of hikers, but if a path looks or could be dangerous, travellers will not see all of the sights they are there to see. They walk with their heads down.

The eastern loop of Hopkins Memorial Forest Loop Trail provides a 3 mile introduction into the Massachusetts outdoors (Figure 1). Hikers, bikers and skiers are all allowed on the trail but horseback riders and vehicle users are not. Unfortunately for potential trail users, water flows through the trail have turned it into a stream bed and catch-all basin. These stream flows and wet spots present difficult or at least unpleasant going: "water is the natural enemy of earth roads, for mixed with dirt it makes mud and mud makes bad going" (Baker 71). The streams help to erode away the trail, causing hikers to walk along the edges of the trail, thereby spreading the problem.

K - no, no, and no again - no wheeled vehicles

In my paper, I hope to assimilate enough evidence concerning this stream flow problem which will led to potential solutions I will propose. With my conclusions concerning trial rehabilitation, I hope, through my position as Outing Club trails manager, to structure some Outing Club trail crew gym classes around reconstruction of the loop trail, to test and hopefully prove my hypotheses about how this problem should be tackled.

Figure 1.


TO BENNINGTON, VT.
HOOSIC
RIVER
ROUTE 7
VERMONT
MASSACHUSETTS
NEW YORK
MASSACHUSETTS
TO TROY, N.Y.
NORTHWEST HILL ROAD
NORTH BRANCH
MIDDLE BRANCH
SOUTH BRANCH
PRIMMER LOT
FORD GLEN BROOK
BIRCH BROOK
BUCKLEY ST
OLD PETERSBURG ROAD
BUXTON BROOK
W MAIN ST
ROUTE 2
TO N ADAMS
TACONIC TRAIL
FLORA GLEN BROOK
ROUTE 2
BEE HILL ROAD
HEMLOCK BROOK
ROUTE 2 AND 7
TO PITTSFIELD
HOPKINS MEMORIAL
EXPERIMENTAL FOREST
WILLIAMSTOWN, MASSACHUSETTS
1961
SCALE-FEET
1000 0 1000 2000

B. PHYSICAL PROCESSES:

The hydrologic cycle is the constant changing of location and condition of water: it evaporates or transpires into the air; precipitates back onto the ground, and moves along the ground as surface water or underground as subsurface water or groundwater. Groundwater differs from subsurface water in that groundwater is where there is a "zone of saturation" (Keller 63), whereas subsurface water also includes water within the zone of aeration. The saturated zone is also called the water table. Water tables can flow uphill as well as down (class discussion).

Water travels in the location it does and goes where it does because of the topography and soils. If soils or rocks are porous, they have many holes and cracks. Permeability is a measure of how easily water travels through a given substance (Keller 64).

If one were to push a measuring stick through the earth, one would encounter zones with different abilities to hold or transport water. An aquifer is land which can produce groundwater if a well is put into place. Williamstown has both shallow and deep aquifers, separated by a thick layer of silt and clay.

There are two types of streams to consider. One is effluent: it is usually perennial. If it flows in the dry season it is because groundwater seeps into the stream bed. Influent streams lie above the water table, and flow after precipitation (Keller 65). Streams are a primary factor in soil erosion. How much sediment they can carry, the area of the streambed, the steepness of the slope and the velocity of their load are all interrelated.

In a forest, soil is designated "the least renewable resource" (Kimmins 221). This generalization is probably true. Soil carries microorganisms and nutrients and provides a stable structure in which vegetation can grow. If soil is eroded away, there is really no way to immediately get it back. New soil must come either from eroded rocks or transported as stream sediment *(or slide in from above)*. This new soil might differ enough from the old in pH, nutrient content, and permeability so as not to be entirely useful to its new vegetation. Also, new soil must come from an area which is now deprived of its own soil. Ultimately, new soil must be created in order to fulfil the gap. This process takes a long time.

In dry soils, water vapor diffuses to the surface, where it condenses. Water vapor travels in a polar direction, from areas of higher to lower gravitational potential, or ability to be pulled to where the gravitational potential is 0, or where saturation occurs, that is, the water table surface (Kimmons 227). Gravitational potential is opposed by matric potential, or capillary and adhesive forces (Kimmons 228). Capillary forces hold water molecules together in small pores, and adhesive forces hold water molecules to other substances, such as soil particles. Loamy soils hold water better than clay soils (Kimmons 228). *value judgement? clay soils contain more water, but it may not be available* When water travels through the soil, it first travels rapidly *slowly, always, until local area is saturated* in its journey to the water table, and then slows as air fills up the pores the water had travelled through (Kimmons 228). When water encounters an local (sometimes called "perched")

impervious layer, a water table is formed, leading to a mosaic of wet and dry spots (Kimmons 272). "Seepage water travels downhill until it joins either a water surface or subterranean body of water (Kimmons 272).

The topography of Hopkins forest was mostly created by glacial action. Its soils are more loam and silt than clay.

This background information about general water and soil principles and physical features of Hopkins Forest is important in understanding on what mechanical principles the details of water flow in the loop trail is based.

good work on hydrology ... but what about information (hydro. + geology) specific to HMF?

C. HISTORY OF THE TRAIL:

In all of the documents I read, no one stated exactly when the trail was built. By looking at a variety of sources, I managed to reason what the history of the trail was, as it is intimately related with the general history of Hopkins Forest. The forest covers approximately 2250 acres in the northwest corner of Massachusetts. It is owned by Williams College and managed by CES. Originally, the forest was owned by people who used it as farmland or later for harvesting trees. In the western part of the forest, where the trail now is, fields were abandoned and succession allowed to occur around the time of the Civil War (Cunningham 8). The farms comprising most of the current forest area were all bought by Amos Lawrence Hopkins around the turn of the century (Hopkins Forest brochure). He farmed in the eastern portion of the forest (Cunningham 8). Many years after Hopkins' death, in 1934, his widow Maria-Theresa Hopkins gave the land to Williams College.

The next year, the college loaned the US Forest Service the forest, with the express intent of "said premises... to be devoted to the investigation of the various problems bearing on the establishment, growth, management, and protection of forests"(speech given be president bestowing the forest to the USFS, July 30, 1935; Cunningham 4). In 1936, "roads were built or repaired so as to be able to have equipment and materials"

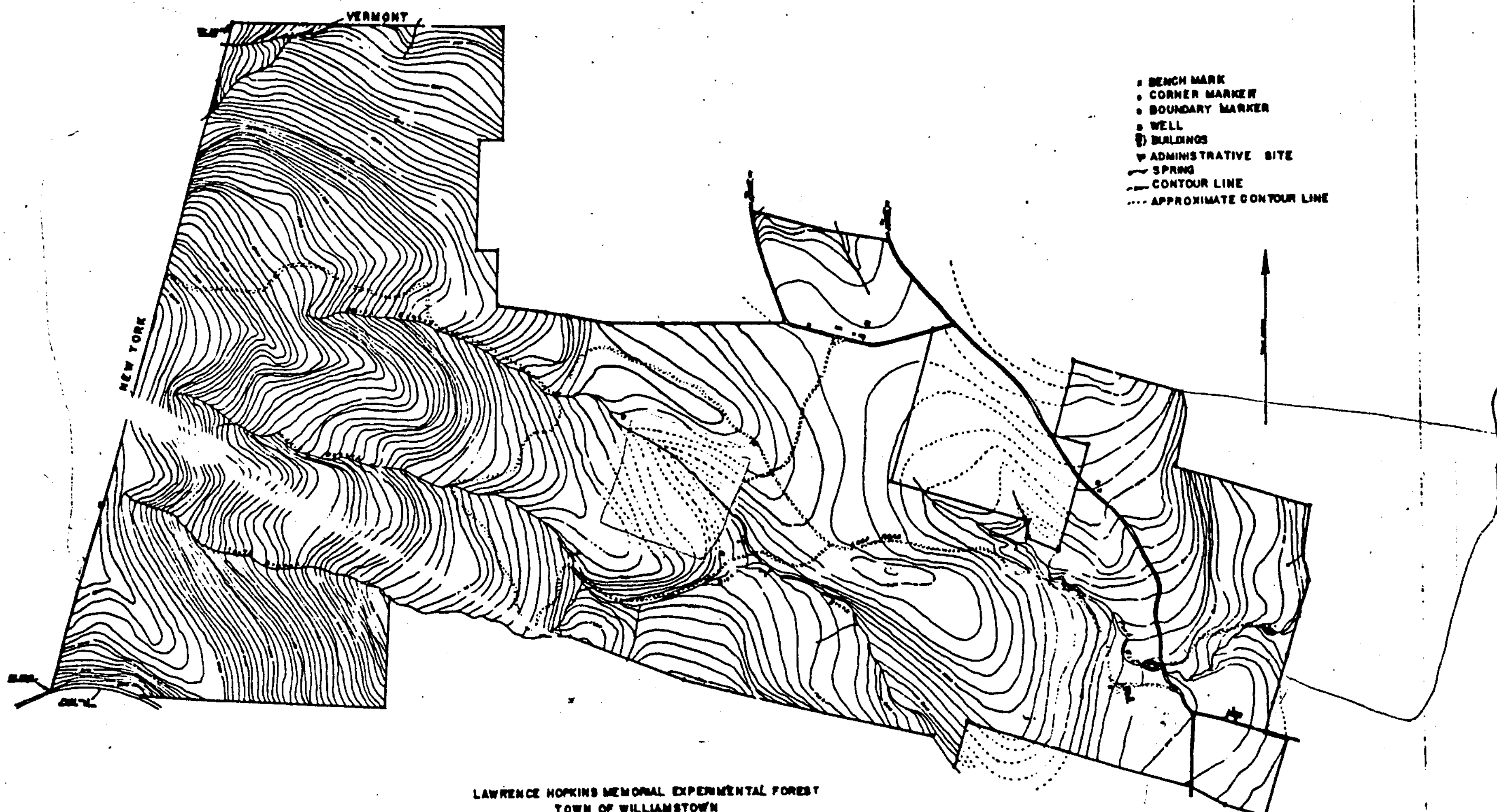
(Cunningham 5). For thirty-three years, the USFS operated the Northeastern Experimental Research Station, with a lapse during World War II. After this lapse, roads were repaired. It was noted that along the roads in the western part of the forest, a four-wheel drive was needed in order to get about. Brush on the Loop trail was cut back at times (Cunningham 8).

I surmise that the USFS built the loop trail in 1936. In a paper by Peter McChesney, he includes maps of who owned current forest lands from the 1800's -1910. In none of these maps does any loop trail appear; only in the USFS survey does it first appear. The trails are definitely there in the 1936 USFS Atlas (Figure 2).

Professor Hank Art has informed me that when the Forest Service returned Hopkins forest to the college, motorcycles were ridden around the loop trail, causing initial ruts in it.

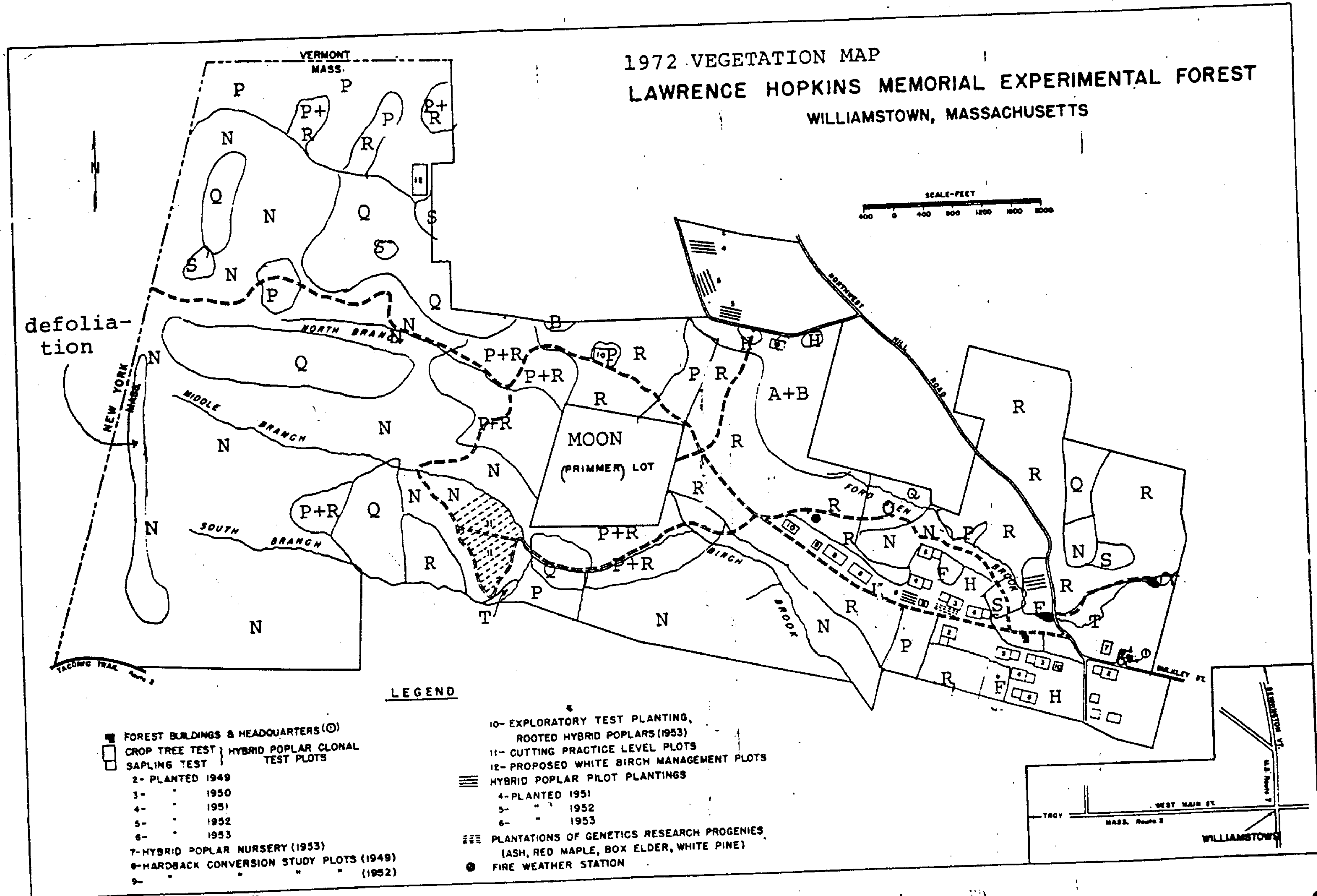
After the USFS returned the forest to the college, the college bought up the last plots of land. It began using the forest as an area for research and recreation, which are the main functions of the forest today. The vegetation around the loop trial is mostly trees planted for a genetics research project (Figures 3 and 4) The loop trial currently is used mainly by hikers travelling to the Birch Brook trail and Taconic crest, going for a stroll or a run, and in the winter by skiers.

Figure 3



LAWRENCE HOPKINS MEMORIAL EXPERIMENTAL FOREST
TOWN OF WILLIAMSTOWN
BERKSHIRE COUNTY, MASSACHUSETTS
NORTHEASTERN FOREST EXPERIMENT STATION
U.S. DEPARTMENT OF AGRICULTURE

Figure 2



For VEGETATION MAP KEY see 1937 map

Figure 3

1972 Basal Area Dominants

Hopkins Forest Section Index

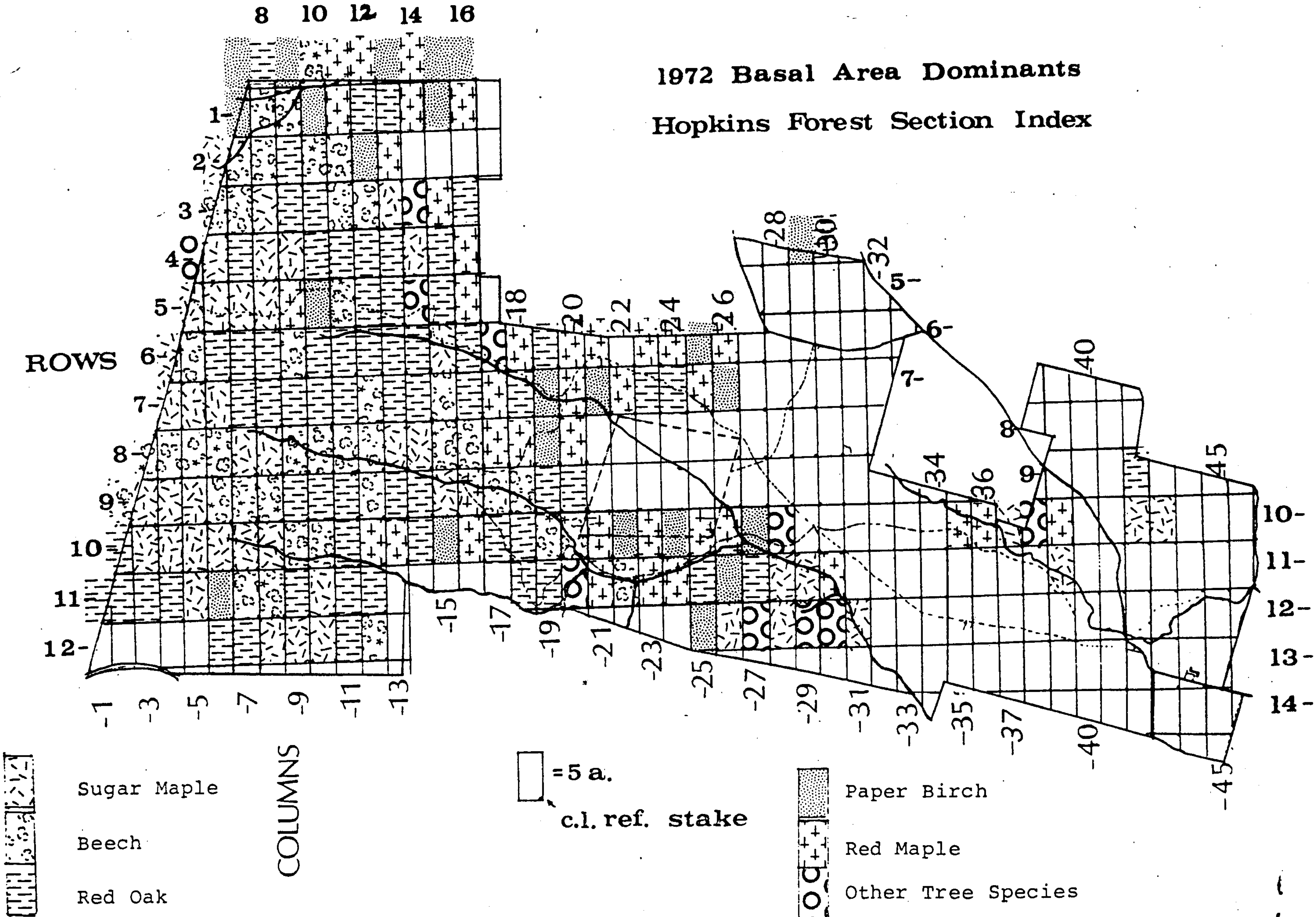


Figure4

D. TRAIL CONSTRUCTION AND REPAIR:

A grounding in basic trail construction principles is necessary in order to understand some of the concepts I will be talking about in my paper. A good trail will allow the hiker* to enjoy the views without having to concentrate primarily on footing and stability. It must have a specific cleared trail corridor. This corridor will prevent vegetation from obstructing the hiker's path and will leave space through which to see whatever is there. There should be an initial total clearance in a box shape along the treadway, and then another foot or so in diameter which should be cleared of obstructing vegetation. The trail should be built in a location which combines opportunities to view nature's splendor, not excessively difficult hiking terrain, hiker safety(Rajala 25) and minimal damage to the natural landscape and wildlife. For example, even though the top of a mountain might seems the ideal place to have awesome views, the vegetation might be too fragile to support multiple hikers.

The constructor must notice the type of soil she is intending to build the trail on. If soil is too compact, it does not have the ability to absorb surface water, leading to a potential spring flooding problem (Rajala 12). The color and size of soils are also

---

* or skier, runner, even rider, but I will concentrate on a hiking and skiing trail and will for clarification call general travellers hikers

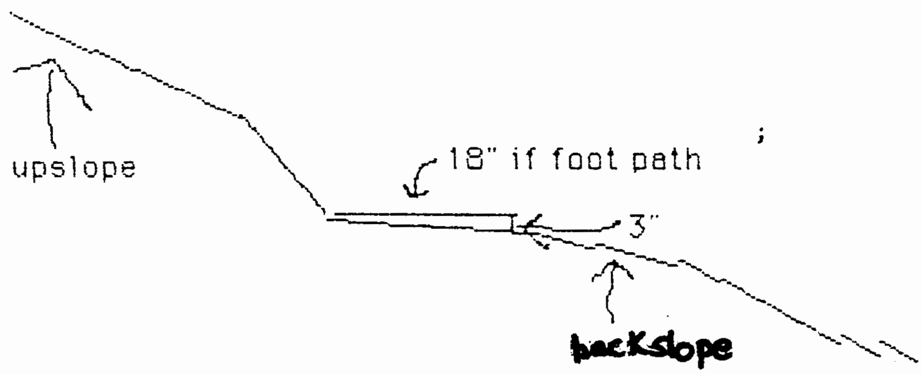
good indicators of whether the area has good drainage or not(Rajala 15).

A trail, even one meant for the most expert of hikers, must be relatively flat, a 10–12 % grade at most (Wonnacott). Otherwise, not only do hikers puff, but they are more likely to erode the soil away by digging their feet into the ground in order to ascend or descend. A trail should wind with the curve of the hill. If the hill or mountain is especially steep and long, switchbacks should be used: the trail should be cut zig-zagging up the slope. With switchbacks in place, hikers will become less fatigued and less likely to cause soil to slide straight down the hill.

however, we all like short, steep pitches and excessive use of promotes "cutting" of same

When building trail on the side of a grade, measures have to be taken to ensure that water runs off a trail crosswise before it has time to gather force and run along the trail. "Trails cut into hillsides present innumerable construction problems and expert engineering advice will be required in each instance" (Ashbaugh). Mr Ashbaugh may be a bit pessimistic, but the seemingly innate desire to climb and to be on top of mountains and hillsides must be reconciled with construction difficulties.

Careful planning of hillside trails must be made. The upslope, the slope directly uphill from the trail, has to be at a different angle than the natural slope, to facilitate water sliding easily down onto the trail as opposed to encountering a sharp break in soil angle (see Figure 5). If there were not an initial change in the upslope, the water might just drop onto the trail in a waterfall, causing quick erosion of the trail. The trail itself must slope



trail model

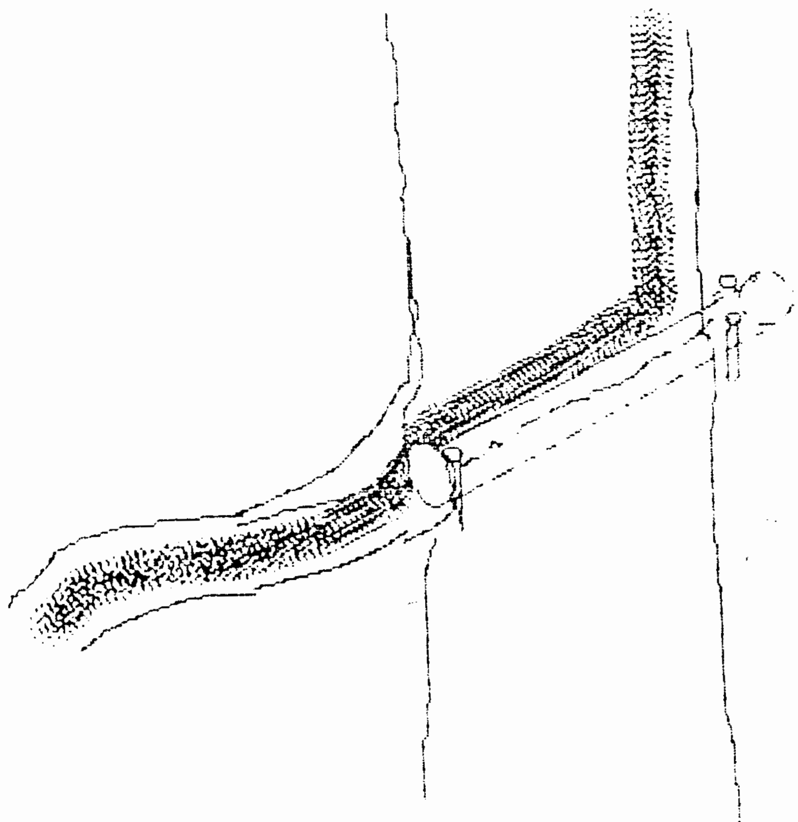
Figure 5

downslope very gently, so water coming onto the trail will run off across instead of along the trail, and so a rut close to the upslope does not form due to downcoming water collecting there because it has nowhere else to go.

Finally, the backslope must be at a gentler angle than the natural slope. If people step there, this act does not destroy the natural slope. Destroying that slope would first of all harm nearby vegetation and second of all cause erosion. As the people pushed away soil, water would take it away. Erosion would be less likely to happen with the backslope existing because pushing this backslope down would merely flatten it out on top of the natural slope. It provides a buffer zone between the walked upon the trails soils and the hopefully pristine natural soils and slope (Colburn).

Even the most carefully made trail will eventually need some form of repair. If the trail lies in a relatively flat, dry place all it should need is an annual clearing of brush. For a trail winding around a hillside, however, more extensive repair methods might have to be undertaken concerning erosion problems.

One of the simpler solutions, one already used on the loop trail, is the placement of water bars on slopes where water would run down the trail (Figure 7). They can be made out of either a log or rocks. The log must be stripped of its bark so that the bark will not decay and the water bar then shift. Usually, logs are used rathern than rocks because it is easier to find them. On the other hand, rock water bars should last longer if properly placed. When positioning a log water bar, it should be placed



need to identify things for reader!

MODEL WATER BAR

Figure 7

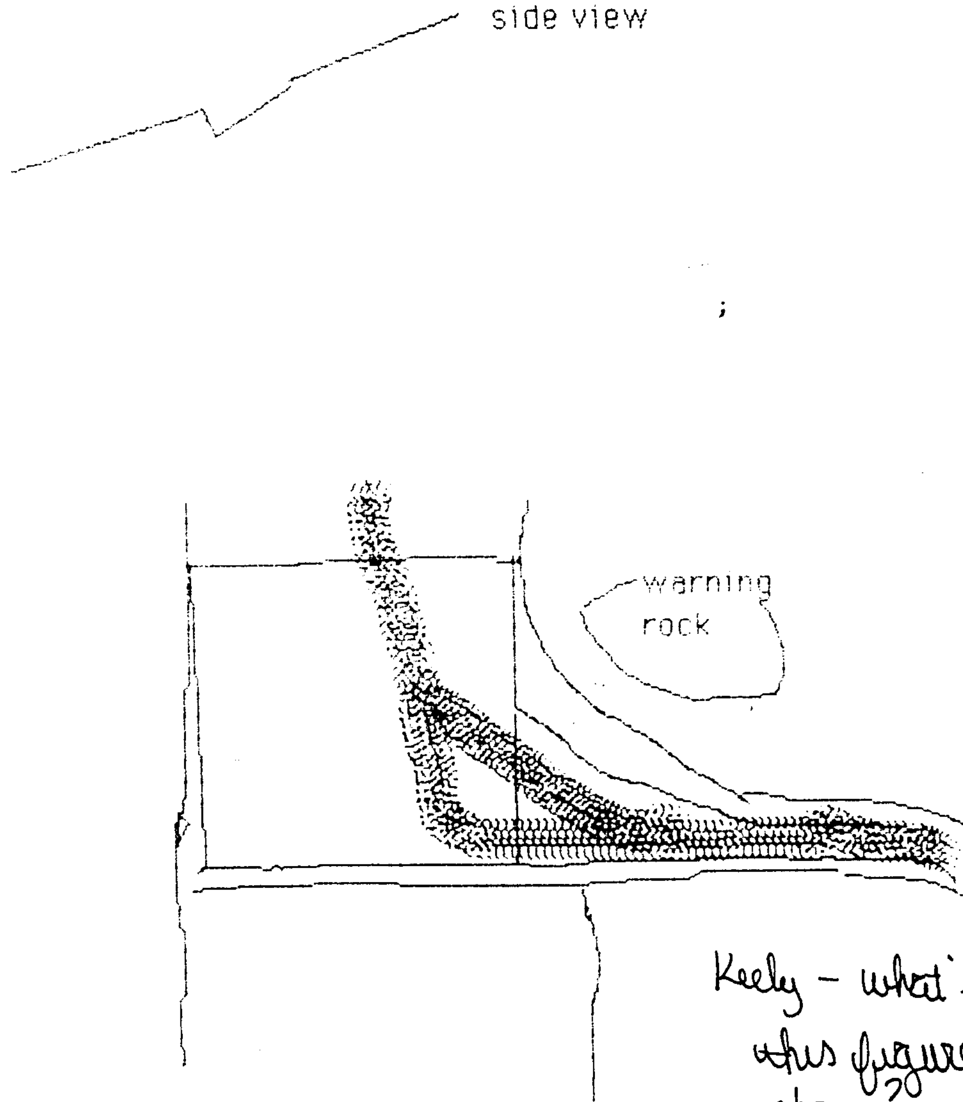
diagonally across the trail in a spot dug out to fit it, held in place be spikes which can be made from tree branches. It must be diagonal because if it were horizontal, high flows of water could gush over it (Rajala 85). At the lower end of the diagonal, a channel should be dug on the uphill side, so water flowing down will run off through the channel (Colburn). The channel must be periodically checked to make sure it is unblocked.

Another way to get water off of a trail is to make a drainage ditch (Figure 8). These are generally made in areas with a slight incline down the trail. With a pick maddox or pulaski, tools with one adze edge, the trail is dug out in a spot so that is gets deeper, perhaps for three feet lengthwise and for the whole width of the trail. Then, abruptly, digging is stopped in a spot and a channel dug to be a runoff point. The channel can be shaped so as to maximize water outflow (Colburn).

(would have to be lined with rock)

If an area is steep and erosion occurs easily by the feet of hikers, stone or wood steps can be built (Figure). These slow down water and help to hold soil in place (Rajala 93). Logs are pinned into position on the ground across the trail, as with water bars, but this time horizontally, and the uphill sides are not trenched, rather filled in. On one side of the steps, a channel can be dug to collect and water, perhaps filled in with rock, so hikers are not tempted to avoid climbing the steps (Rajala 93). Rock steps are preferred, because they are more stable. The rule is that if you can carry a rock, it's too small. Large, preferably

good point!



Keely - what's this figure show?

MODEL DRAINAGE DIP

Figure 8

flat, rocks can be layered. Again, measures must be taken to ensure that hikers do not avoid steps and cause further erosion.

A final solution is rock or wood cribbing, used when there is gullying (Rajala 107). To prevent more trail from falling into the trench, rocks or wood are used along the side of the trail nearest the gully. It serves first to prevent people from walking there are second to lend stability to the side of the trail.

If the trail is in a wet area which is not going to go away, one solution besides building bridges is log courduroying (Rajala 142). This is preferable for skiers because it can be wider and relatively flat. This is basically simply a long bridge. Logs are placed like horizontal water bars put right next to each other, creating a flat dry area above a wet one.

DPD doesn't like these 'cuz they hold water, preventing the area from drying out -- why not rock cribs instead?

If no other options are possible, the trail is too far eroded, then relocation must be considered, accompanied by revegetation of the old trail area. A new trail must be constructed in a better location-- less steep and better drained-- than the old one. Care must be taken to have the new trail disturb the environment as little as possible. Once the new trail is constructed, the old one must be put to rest, and natural vegetation allowed to grow upon it. This involves first disguising the ends of the trail so that people are not tempted to walk there. Methods include planting trees, even dead trees (who would believe a dead tree stands in trail?), and dragging fallen trees across the old trail. Once the old trail has been disguised, it can be left to nature's healing processes. (if you get most of the water off)

III. **METHODS OF INVESTIGATION**:

Several afternoons a week, ever since spring break, I have ridden out to Hopkins Forest and hiked in to the stretch of the loop trail I was working on. I went along the trail, making localized diagrams of what the trail looked like in terms of where water was or was not. I did so in order to get a visual perspective on why the water might be where it was. To further investigate, I hiked above and below the trial to see exactly where water might be flowing from, and to where it might be going.

To measure the flow of the water running through the stream, I timed the length of time it took for a cup to fill. This was difficult to do, because first there were not always distinct waterfall-type-flows, and second after late April most of the waterflows dry up, leaving only the main wet areas and stream. All of my field work was supplemented by outside research in Kellogg house and the Williamsiana collection. After determining what the sources of water were, I used previous knowledge I had of trail construction from my experiences on trail crews to write proposals concerning how the trail might be reconstructed.

K.-This is a well informed introduction!

IV. OBSERVATIONS OF THE TRAIL ITSELF:

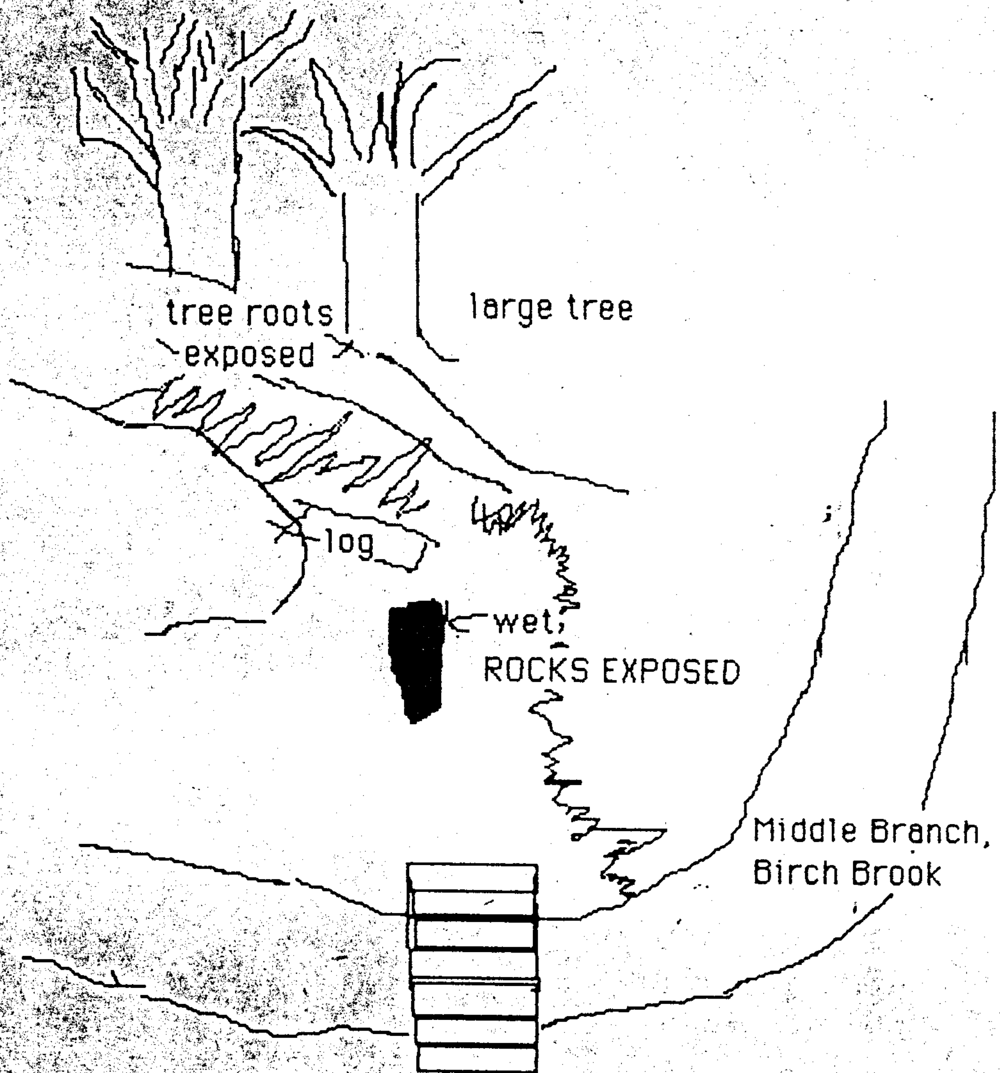
/ sliding scale or all the same?

The diagrams I constructed each correspond to a 5-20 meter section of the trail. In this portion, I will take each diagram, or "site", individually, and discuss further exactly what the physical status of each section of trail is. The beginning of one site is the end of another. In some cases there are distinguishing landmarks such as large trees or waterbars to characterize this correspondence. Even if such landmarks are not visible, the rule still holds.

SITE 1: This is the first section encountered when travelling west on the southern end of the western loop, where the trail crosses the Middle Branch of Birch Brook for the first time. When I first went there on Sunday, April 8, 1990, there was a veritable stream running where indicated on the diagram. I measured the amount of time it took for the flow to fill a cup measure at the point where the stream emptied onto Birch Brook. That time was 10 seconds. It was rather a slow trickle. In fact, by April 16, it had dried up in the lower part, leaving wet only the upper part, where the zig-zags are wider on my diagram. The fact that the part of this water did not last even a week led me to believe that this stream was caused by seasonal runoff (a flood during snowmelt here!). The direct source of the water, I hypothesized, was the same as that for sites 2 and 3.

SITE 2: This site climbs steeply through an area with high banks. If water hits the ground uphill from the trail, it can either run to the trail or else directly to Birch Brook. Water only actually was running here until the sixteenth, at which point it became either standing or very slow moving water. Through May there was always water underneath or near the surface of the ground, sometimes hidden only by a layer of leaves. The trail as it stands in this spot is an ideal place for water to congregate because of the steep banks which do not allow any to escape once it has settled into the trail ground. Water continues around from this steep part to the wet channel in site 1, with some also running down the west side of the trail. Once this water on the western side of the trail has passed the area of steep banks, it continues in a straight line of of trail area. People have taken to travelling on the eastern side of the trail, proven by the many footprints in the mud, not all of them mine.

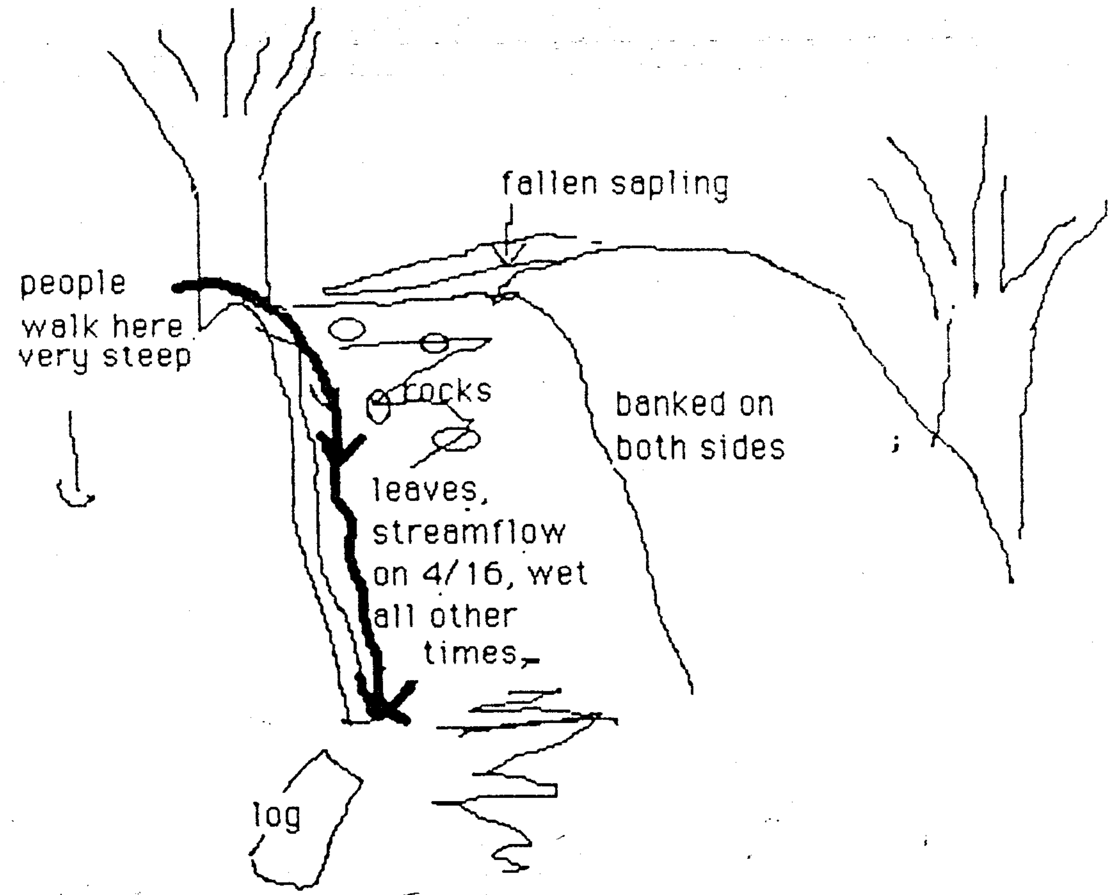
SITE 3: The wet area on this section of trail is thoroughly covered by leaves. On the uphill side, there are many trees, including fallen ones. The uphill slope rises very gradually for about 20 meters, then steepens. The source of most of the water in this area seems to be a wet patch on the uphill side, at the very beginning point from where the water began. Tracing this wet spot uphill, and there seems to be a series of wet spots all along the hill. I postulate that these spots eventually let water seep down, which collects in the trail, perhaps the trail is now a part of a localized if not general water table. This water does not exit underneath the trail because of cohesion and adhesion underneath the trail, and it does not run off above the trail because there is the slightest of rises on the downhill (east) side of the trail. Once the underground seepage inflow stops, and the trail rises slightly, it dries off.



tree roots
exposed
large tree
log
wet;
ROCKS EXPOSED
Middle Branch,
Birch Brook

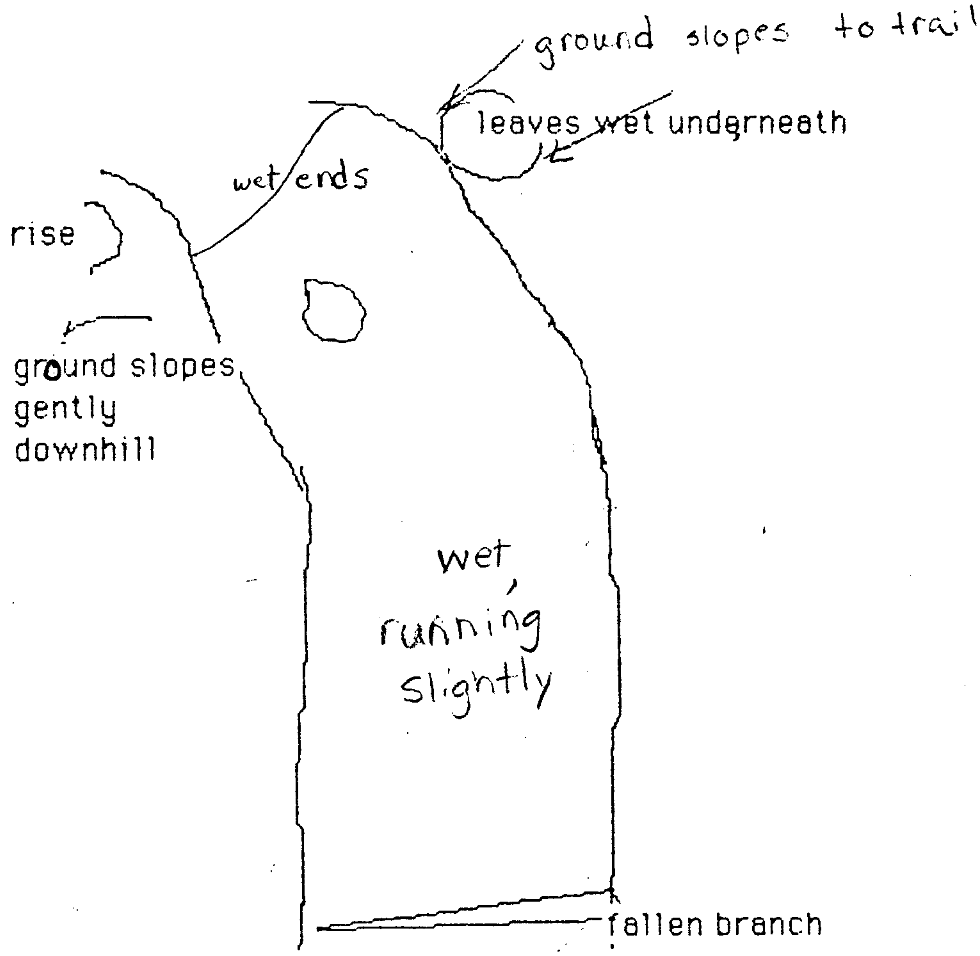
Site 1

N →


fallen sapling
people
walk here
very steep
rocks
banked on
both sides
leaves,
streamflow
on 4/16, wet
all other
times.
log

Site2

E<-W


ground slopes to trail
leaves wet underneath
wet ends
rise
ground slopes
gently
downhill
wet,
running
slightly
fallen branch

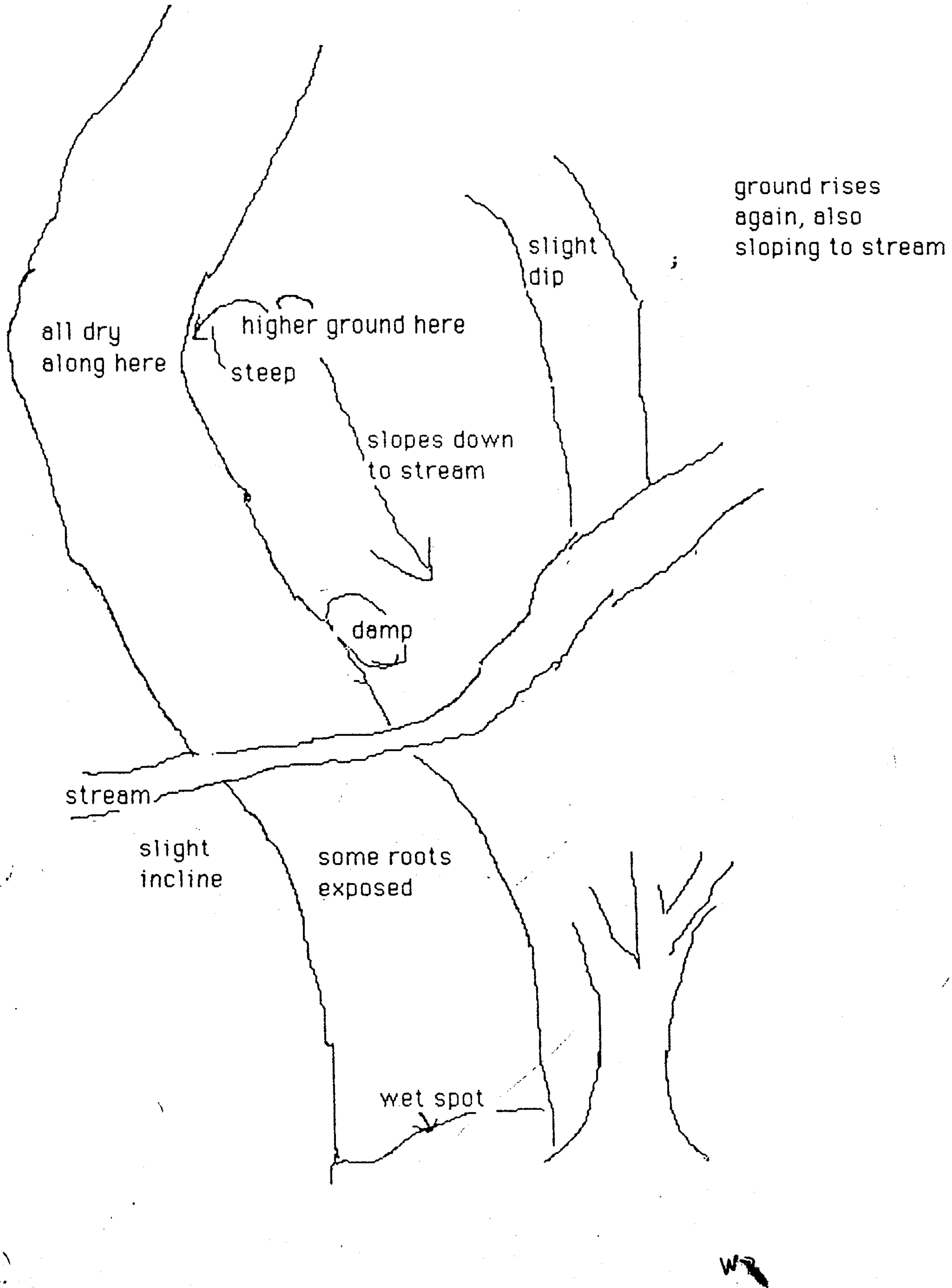
site 2

W→

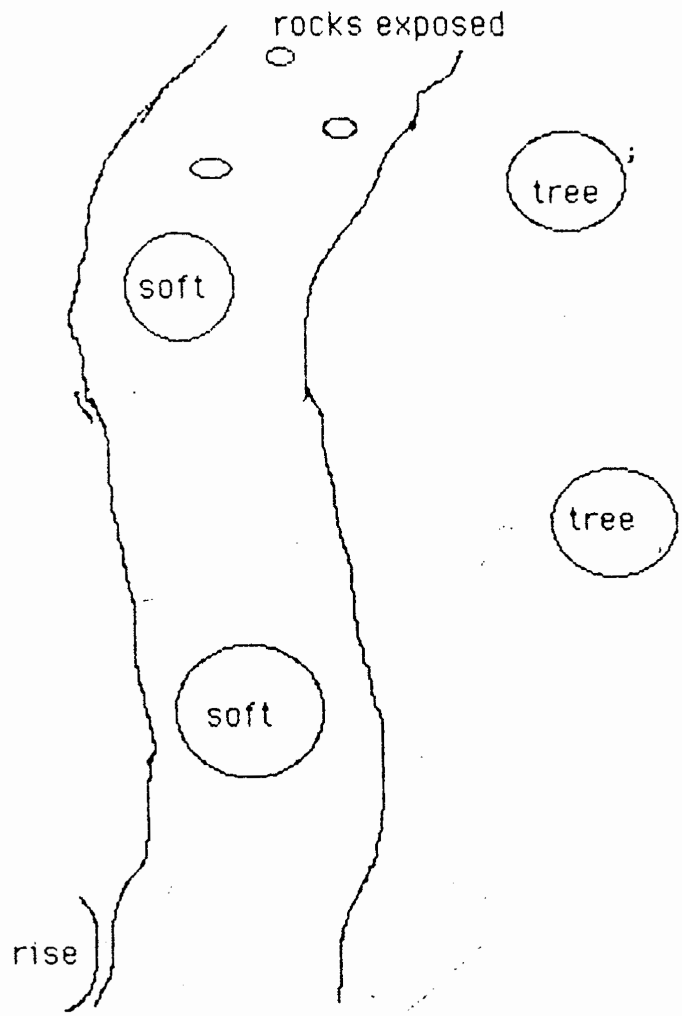
SITE 4: As stated in the site 3 description, the trail rises slightly and subsequently dries out. Also in section 4, there are roots exposed which stabilize the trail. Water coming down the hill to this spot would have dynamics toward either the stream or the wet section of trail, because of the high to low gravitational potential. On the opposite side of the stream (time to fill cup 1.1 seconds), the trail is also dry. There is minimal downhill flow of water to this spot because of the topography of the site. To the direct west side of the trail, there is a sharply defined hill, but directly as it reaches its summit-- a few feet vertical distance-- it drops off on the other side. This creates a channel in which water coming down the western hill would collect and dump in the stream. It is also then not a part of any water table. So even though this part of the trail is relatively steep, the land surrounding it puts it in a dry position.

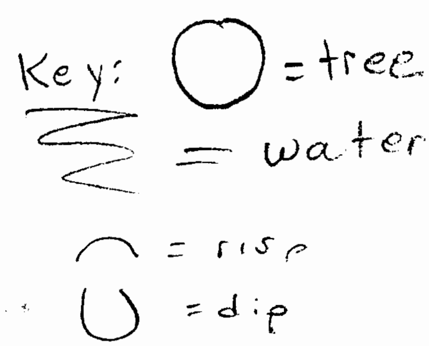
SITE 5: This site is also fairly dry. It is probably so because the uphill water would be directed toward the stream still. There are two soft spots. These spots seem to be soft not simply because water is running into them, in which case they might be more toward the uphill side, but because there is a water table somewhere relatively near underneath them, and that is may rise temporarily. There is no real water there, even when the ground is pressed down upon, but is merely a spot where there is some contact with a water source. (capillary fringe !)

SITE 6: Even though there is a water bar at the bottom part of this site, it seems only to become a collection point for water uphill(the hill is very


ground rises
again, also
sloping to stream
slight
dip
all dry
along here
higher ground here
steep
slopes down
to stream
damp
stream
slight
incline
some roots
exposed
wet spot

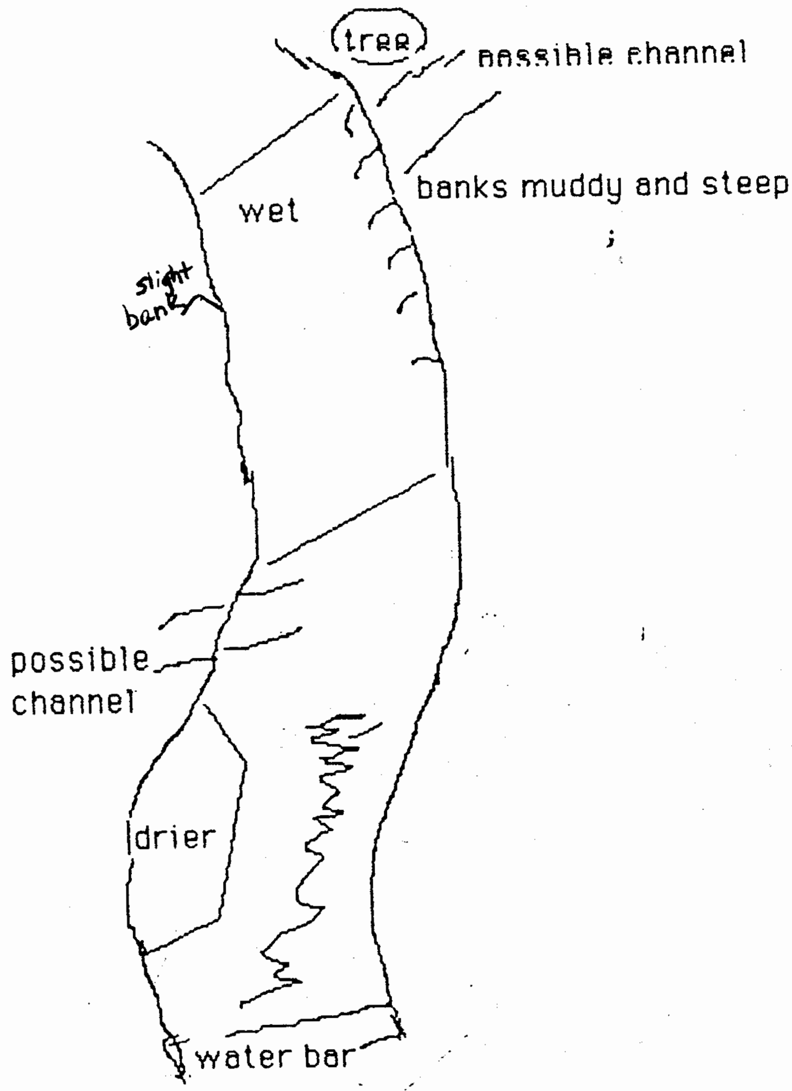
Site4


rocks exposed
tree
soft
tree
soft
rise


Key:
= tree
= water
= rise
= dip

Site 5

W↗

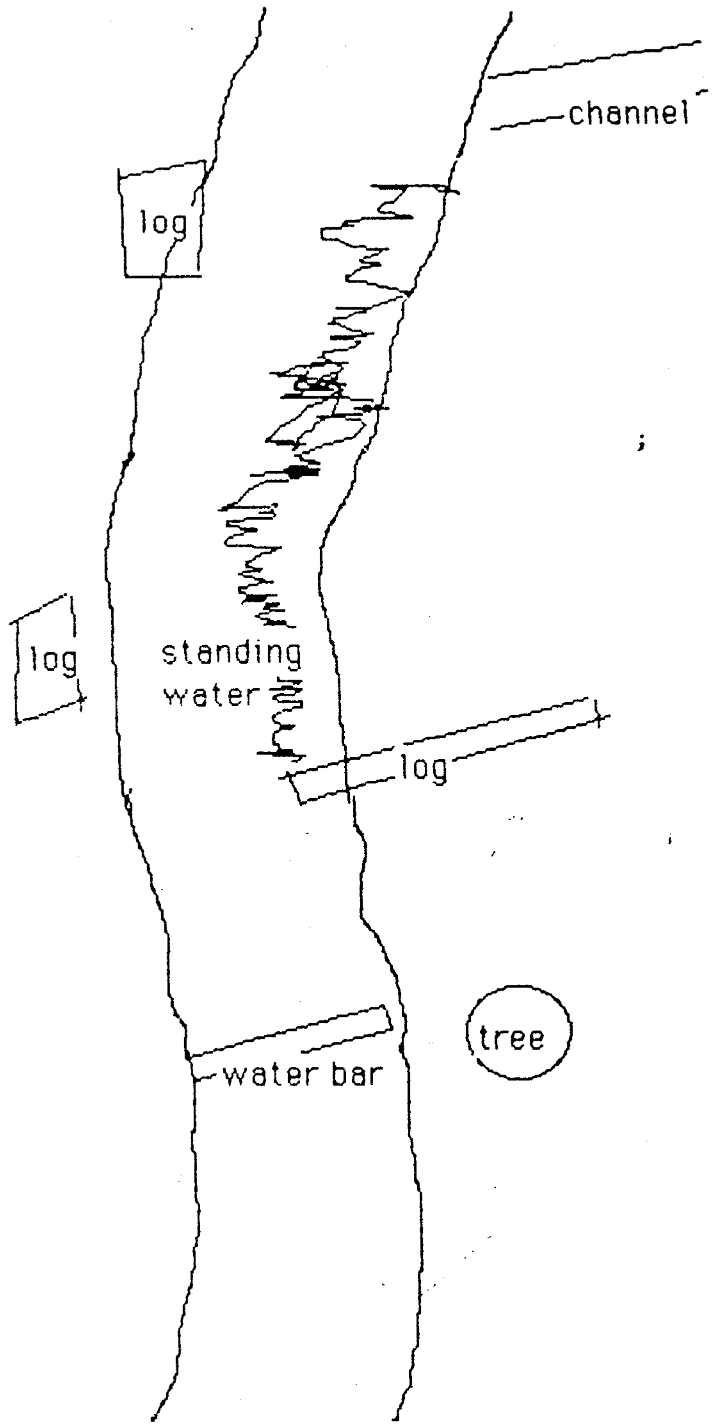

tree
possible channel
banks muddy and steep
wet
slight bank
possible channel
drier
water bar

Site 6

N→

slight) from it. This is the case in part because the water bar has poor drainage off of the site, so water has nowhere to go. The upper part of this section is extremely wet. Again, the trail has become a collection point for any water coming down the hill (there seems to be a possible channel coming from the uphill side). Because the trail is not at all steep, perhaps less than a percent in slope rise, the water does not immediately run off. So once some of the water from ~~a~~ spring run-off (or winter snowmelt) stays, the water in the trail becomes a collection point for more water, as described in the introduction. Some of this water might run off the channel drawn on the left side of the page, which is why the lower portion of the trail, which is also steeper, would not have as much permanent water. This characterization is also exemplified by the change the water has done to the ground: in the lower half, it has created a channel which is filled with water because the water bar needs repair, in the upper it has formed a mud basin, since it isn't really attempting to go anywhere.

Site 7: Water seems to run in here from the channel, as a slight collecting channel from the slope above it, Again, the water stops in the trail because of poor drainage. The down slope bank is slightly higher than the trail itself, and the trail is not very steep, to allow for easy drainage. The water eventually disappears from the trail because the south side of the trail gets lower and the trail steeper, so water falls away more easily. Water could then either run off of the south side of the trail, to one side, or else run directly down, underneath the trail.



Site 7

N→

Site 8: This site is relatively dry. It apparently has no contact with the water table. Most surface or subsurface water coming down the hill would probably get caught in a slight basin uphill of the trail. Any water coming down the last downhill to the trail might travel under the surface in such a path so that it will not run through the trail,. The roots also help stabilize the trail even though it is rather a climb in this section. The water bar is meant to catch any water coming down the hill onto the trail, but was not obviously necessary, since the trail was dry even at a time when other parts of the trail were not.

Site 9: This site is one corner of the loop, as shown on the general map (Figure). It runs through a hemlock grove. It is dry here for several reasons. First, the roots of the hemlock trees run across the trail and help stabilize it against erosion. Second, although the ground slopes down slightly from the north to the trail, it goes down much steeper to the east. Most water would have a tendency to flow in that direction, even water landing near the trail. The ground also falls steeply away to the south of the trail, as the South branch of Birch Brook is nearby.

Site 10: The ground on either side of this section of trail is relatively flat, with the east side sloping down away from the trail. Many tens of meters west of the trail the ground rises sharply, but any water running down from there would be more likely to collect nearer to the rise, since it is all pretty flat there. Water would not have enough momentum to rush to the trail, rather would soak in one place. The water bar in this section has no