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THE CONSTRUCTION OF PLATFORMS AND BRIDGES FOR FOREST CANOPY ACCESS

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ABSTRACT. A modular construction system of bridges and platforms has been designed to facilitate access into forest canopies. This technique creates permanent sites at moderate cost for long term observations and data collection, and allows collaborative research by a group of researchers within one region. Walkways have been constructed in both temperate and tropical forest ecosystems. The approximate costs, safety concerns, and construction specifications are described for two sites: one in subtropical rain forests of Belize, Central America, and one in a temperate deciduous forest at Millbrook, New York.

INTRODUCTION

Research in forest canopies has been limited by logistic constraints of access (reviewed in Mitchell 1982, Lowman and Moffett 1993, Moffett and Lowman 1995). Over the past decade, several inexpensive techniques have been developed, but they usually are restricted to solo efforts. These include single rope techniques (Perry 1978, Lowman 1984, Nadkarni 1984); ladders (Selman and Lowman 1983, Gunatilleke et. al. 1994); and towers (Odum and Ruiz-Reyes 1971, Zotz 1994). Devices that facilitate research by a group of scientists simultaneously have also been developed, but usually are considerably more expensive (e.g. the raft and dirigible (Hallé and Blanc 1991)), construction cranes (Parker et al 1992)). In essence, there appears to be a distinct correlation between expense of access method and number of scientists that can safely utilize

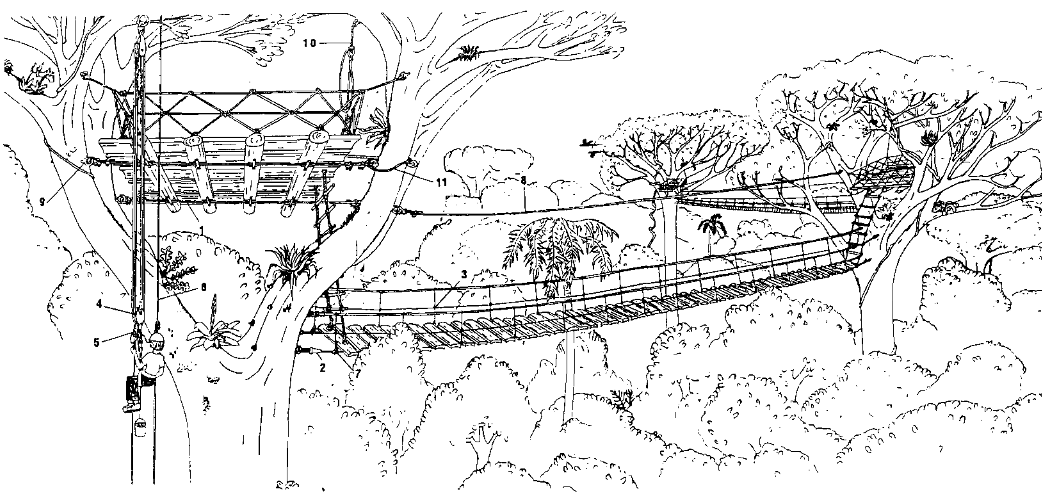

FIGURE 1. Illustration of the modular system of construction of bridges and platforms. Components shown include: A. 3/8″ stainless steel wire rope (12,000 lb. tensile strength); B. Strand vice—a hardware item that allows precise measuring and tensioning of a cable while it is being installed; C. Stainless steel net clamp—clamps two cables together at right angles; D. Block and tackle—over 10,000 lb. tensile strength; E. Ascender—device to prevent unintentional slide down rope; F. Redundant safety rope—makes users feel safer during ascent; G. Bridge clamp—clamps onto bridge support cable providing a connection to the vertical side cables and prevents unnecessary flexing of cables; H. Cable for attaching safety lanyard to when walking on bridge; I. 5/8″ × 18″ drop forged galvanized steel eye bolt (17,500 lb. tensile strength); J. Adjustable rope safety lanyard; K. Redundant cable provides extra security at all major connections.

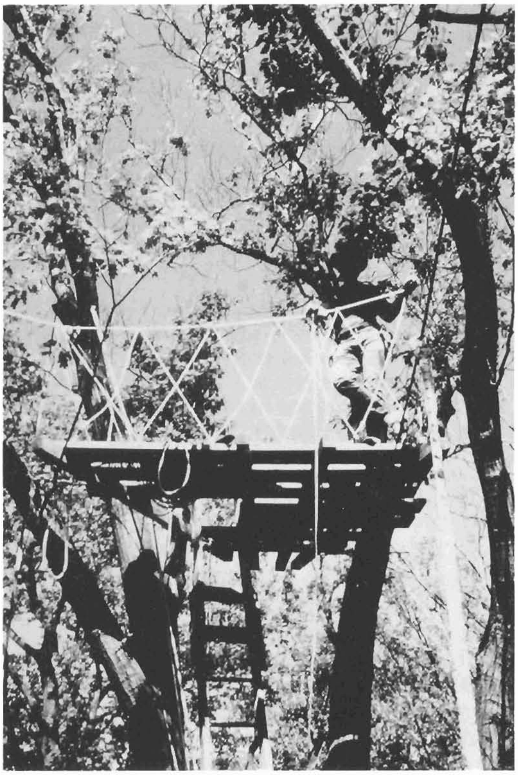

FIGURE 2. The simplest structure that can be built is a single module. This platform module is suspended on stainless steel cable at 26 m height in a red oak (*Quercus rubra)* at Hopkins Forest, Williams College, Massachusetts.

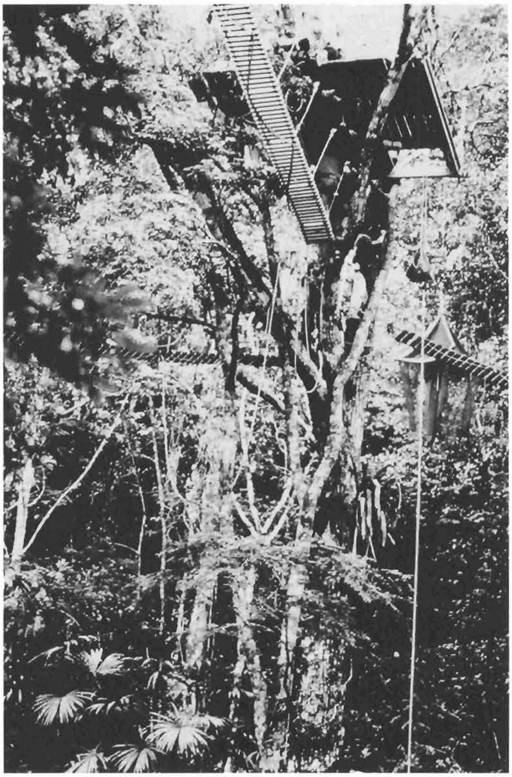

FIGURE 3. A more complex structure includes both bridges and platforms, such as this structure at Blue Creek Preserve in subtropical rain forest, southern Belize.

a common device (see Table 1 in Moffett and Lowman 1995).

Single rope techniques (SRT) are probably the most frequently used method of canopy access. As a canopy researcher and arborist, respectively, for over 15 years, we have been both enchanted and frustrated by SRT. It offers the flexibility of frequent and easily replicated access to canopies, but has obvious limitations: climbing is unsafe during the dark or during inclement weather; collaborative work is practically impossible; observations over long time durations can be quite uncomfortable; horizontal access is limited; and delicate measurements are impeded by the swaying motion of the rope.

Walkways offer an alternative means of studying forest canopies in a more comfortable, permanent fashion, thereby facilitating long-term and collaborative studies that are not feasible with ropes, or in cases where rafts and cranes are not affordable. With the modular system of design described below, it is possible to construct systems that offer scientists an opportunity to replicate both within and between tree crowns, and to conduct repeated measurements over time and space. These modular systems, consisting of interconnected bridges and platforms (Fig. 1), are of moderate cost and provide very easy access to users over a relatively long lifespan.

METHODS OF SITE SELECTION AND CONSTRUCTION

Site selection must be made with respect to integration of both engineering and biological considerations. Engineering constraints include:

1. selection of a forest site of mature, healthy canopy trees within close proximity (walkways and platforms are not safe if built in trees that are small or show signs of crown dieback or trunk rot);

2. use of canopy trees with upper branching systems that are conducive to support of platforms;

3. selection of a stand of trees with a potential

FIGURE 4. Temperate forest walkway site, consisting of two platforms connected by a bridge with access by hardwood ladder, Hopkins Forest, Williams College, Massachusetts.

FIGURE 5. Subtropical rain forest walkway site, including five platforms, three bridges and four ladders interconnected over a stream at Blue Creek Preserve, Belize.

for expansion of modules (the minimum operational design consists of one bridge and one platform); and

4. avoidance of close proximity to edges and treefalls, since these aberrations in the canopy create wind patterns that may lead to damage of the trees in the vicinity of the walkway.

Biological considerations are equally important, when research is the major function of the structure. Biological factors include:

1. selection of a stand of trees that is representative of the composition and diversity of the forest type under study;

2. placement of the bridges and platforms to enable maximum access to foliage and crown space, but with minimal disturbance to the crown architecture;

3. physical dimensions of the structure that are conducive for the intended research; and

4. rigorous standards of construction that minimize impact on the ground and the understory, as well as on the canopy.

The minimum aerial construction module consists of one platform or one bridge (Fig. 2). We have found that two platforms with an aerial bridge connecting them maximizes research opportunities for the cost. A slightly larger system will enable researchers to replicate both within and between tree crowns, which improves the rigor of ecological sampling (Figure 3). The bridges are strung between trees, with a maximum expanse of approximately 30 m. The hanging bridges consist of grooved aluminum or treated wooden treads attached to 3⁄8″ galvanized steel cable of the type used in aircraft (14,400 lb. tensile strength). Hand rails are made with 3⁄8″ GAC (galvanized aircraft cable) webbing between the rails and the ties strung with 3⁄16″ GAC with a 4,200 lb. tensile strength. The platforms are constructed of aluminum beams or pressure-treated wood suspended on the same 3⁄8″ cable (referred to as multi-strand cable) used in the bridge construction. The platforms have 1⁄2″ polyester combination rope webbing (6,000 lb. breaking

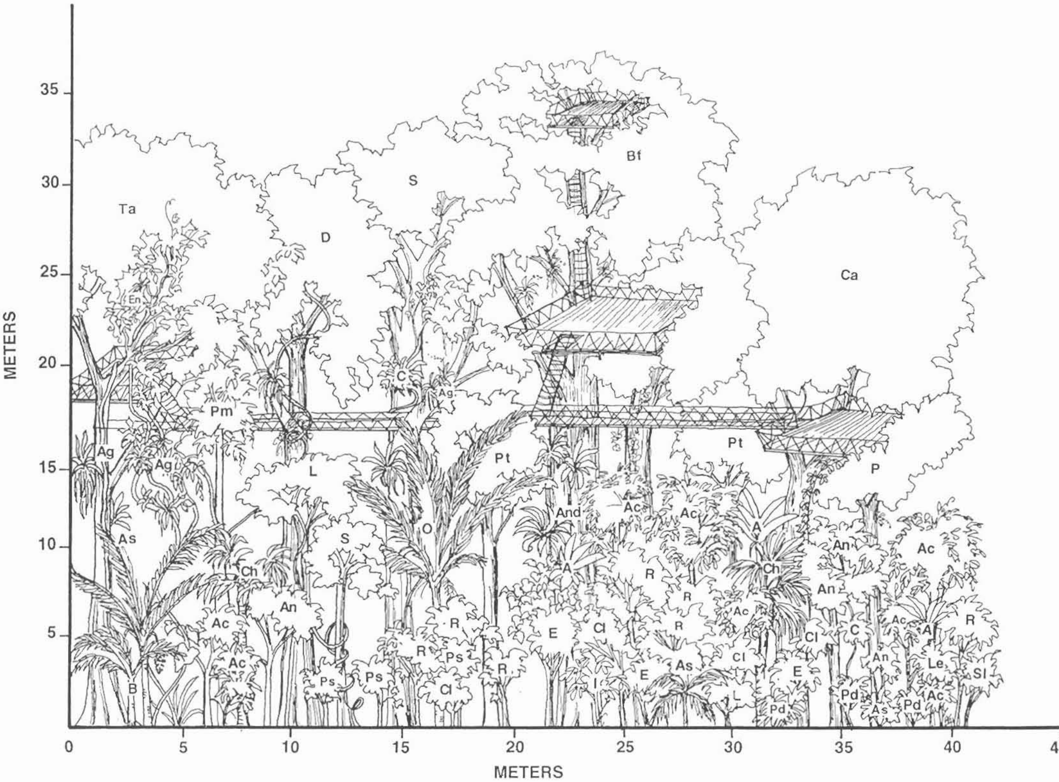

FIGURE 6. Illustration of the subtropical rain forest walkway system, showing the extensive access to different tree canopies made possible through careful design of the system. Plants include: A—*Anthurium* sp.; Ac—*Acacia* sp.; Ag—ant garden; An—*Andira inermis*; And—*Androlepis skinneri*; As—*Astrocaryum mexicanum*; Al—*Asplenium serratum*; B—*Bachtris* sp.; Bf—*Bernoullia flammea*; C—*Clusia* sp; Ca—*Calophyllum brasiliense*; Ch—*Chryosophila argentea*; Cl—*Clavija* sp.; D—*Dialum guinensis*; E—*Eugenia* sp.; En—*Entada monostachya*; I—*Inga* sp.; L—*Lonchocarpus* sp.; O—*Orybignya cohune*; Pd—*Pimenta dioica*; Ph—*Philodendron* sp.; Pm—*Pseudolmedia* sp.; Ps—*Psychotria grandis*; Pt—*Pouteria torta*; P—*Pterocarpus officianalis*; R—*Rinorea* sp.; S—*Sebastiana* sp.; Sl—*Sloanea* sp.; Ta—*Terminalia amazonica*. Blue Creek, Belize.

strength), including hand rails. The webbing is strung between the platform floor decking and the rails.

This method of suspension construction has been chosen to avoid the possibility of structural members rubbing against the tree limbs when the trees move in the wind. This protects both the wooden structure and the tree from damage. The cable strength provides an extra measure of safety over other construction methods that might be considered. We have constructed several walkways successfully in different forest types using this precaution, because it minimizes impact upon the foliage, boles and tree architecture.

In temperate deciduous forests, we have constructed four systems: oak-maple-beech forest at Williamstown, Massachusetts (Fig. 4); oak-maple forest at Millbrook School, Millbrook New York; beech-hickory forest at Hampshire College, Amherst, Massachusetts; and three replicate sites of temperate deciduous forest at Coweeta Hydrological Reserve, North Carolina.

In tropical environments, we have constructed two systems, one in Blue Creek, Belize which was filmed extensively as part of the Jason Project for Science Education during 1994 (Fig. 5); and one near Equitos, Peru, on the upper Moxx River as part of an ecotourism venture.

CONSIDERATIONS OF COST. We have costed our designs by modules, with the idea that different budgets and varying architectural features in a stand will determine the numbers of bridges and platforms to be utilized in a site. The materials have been priced separately from labor, because the latter will vary with location. The cost of materials may also vary if extensive shipping to remote sites is required. Over time, the inflation of costs reported here can be estimated based upon the date of this publication.

The total costs of construction of four platforms and three bridges, plus three ladder systems in the subtropical rain forest of Belize was approximately $32,000 in 1994. Because this walkway system was being used for a major film production, several special features were included: rubber grommets between the rungs of the bridges, to minimize clanking of the aluminum; a Bosun's chair to demonstrate this special mode of canopy access; and an Eagle's nest above the canopy for observations of flowering events throughout the entire valley. The platforms were situated at a range of heights between 27 m and 42 m, and the bridges ranged in length from 12–25 m (Fig. 4). In total, over 10 canopy trees and over 25 understory trees were accessible from this structure (Fig. 6).

In contrast, a more modest access system at Millbrook, New York was completed for $20,000 in 1995. The platforms were situated at 10 m to 25 m height, and three bridges spanned 56 m in total. This costs for this system are itemized in the appendix.

Discussion

Although the rigors of winter are harsh for the temperate sites, the problems of humidity and moisture in the tropical sites are probably more challenging. The use of stainless steel cable and rot-resistant wood is advocated for major support cables in all situations for reasons of safety and longevity of structure.

There are two potential drawbacks to the use of bridges and platforms for canopy research. First, the structures are permanent and it is not feasible to shift them to new locations for purposes of comparing different sites. Second, there is a possibility that organisms in the canopy will utilize the bridges for enhanced mobility; however, we have not (in our five years of experience) observed any such behavior to date. (Lianas probably provide similar mobility.)

We are happy to discuss designs and give advice on any prospective canopy access project. We are also coordinating the collective maintenance of these structures, and a collaborative network of data collection that is developing at each site. The next decade should bring about the advent of a productive network of walkways, yielding comparative results about canopy processes.

Literature Cited

Gunatilleke I. A. U. N., C.V.S. Gunatilleke, and S. Dayanandan. 1995. Reproductive biology of Sri Lankan Dipterocarps. Selbyana 15(2): A9.

Hallé F. and O. Pascal. 1991. Biologie D'Une Canopée de Forêt équatoriale—II. Rapport de Mission: Radeau Des Cimes. Réserve de Campo, Cameroun. Avec Le Parrainage Du Ministére de la Recherche et de la Technologie.

Lowman M. D. 1984. An assessment of techniques for measuring herbivory: is rainforest defoliation more intense than we thought? Biotropica 16(4): 264–268.

Moffett M. and M. D. Lowman. 1995. Methods of access into forest canopies. Pp. 1–24 *in* M. D. Lowman and N. Nadkarni, eds., Forest Canopies. Academic Press, San Diego.

Nadkarni N. M. 1984. Epiphyte biomass and nutrient capital of a neotropical elfin forest. Biotropica 16(4): 249–256.

Parker G. G., A. P. Smith, and K. P. Hogan. 1992. Access to the upper forest canopy with a large tower crane. BioScience 42: 664–670.

Odum H. T. and J. Ruiz-Reyes. 1970. Holes in leaves and the grazing control mechanism *In:* H. T. Odum and R. F. Pigeon eds., A Tropical Rain Forest. U.S. Atomic Energy Commission Rio Piedras. Pp.I-69 to I-80.

Perry D. R. 1978. A method of access into the crowns of emergent and canopy trees. Biotropica 10(2): 155–157.

Selman B. J. and M. D. Lowman. 1983. The biology and herbivory rates of *Novacastria nothofagi* Selman (Coleoptera: Chrysomelidae), a new genus and species on *Nothofagus moorei* in Australian temperate rain forests. Aust. J. Zool. 31: 179–91.

Zotz G. 1994. Ecology and demography of vascular epiphytes. Selbyana 15(2): A25.

Appendix 1

Budget for Canopy Access Structure at Millbrook School, Millbrook, New York

This appendix costs out materials for 3 (8′ × 8′) platforms with rope hand rails and retaining rope-net, aluminum ladder access, and 168 feet of hanging cable supported bridge in 3 spans. (This original design was altered slightly to four platforms after arborists had examined the structural features of the upper canopy at the site; but the budget and equipment list remained the same.)

Bridges. This part of the walkway system consisted of 7 cables running between two trees. The two lowest cables held up the foot treads which were fabricated from pressure-treated lumber (other naturally resistant wood or aluminum are also sound materials). The top cable, which is located about 7′ above the bridge treads, is a 3/8″ safety cable to which walkway users are tethered while they remain on the bridges. Two 3/8″ cables were located 4′ above the foot tread support cables and served as hand rails. Two more smaller cables were located half way between the foot cables and the hand cables; together, with vertical cables connecting the hand and foot cables, they provided steel nets on the sides of the bridge.

Four additional cables, which are not part of the bridge structure, were used as guy wires to counterbalance the weight of the bridges on the trees.

PLATFORMS. The platforms consisted of 4″ × 6″ pressure-treated southern yellow pine joists with 2″ × 6″ pressure-treated decking all supported by two 14,200 lb. tensile strength cables (and in some cases, four cables). The platforms had polyester rope retaining netting surrounding them and a security cable above which users can attach.

Materials key: DFG = drop forged galvanized; GV = galvanized.

Description	Price
34 ¾″ × 18″ DFG eye bolts	$ 448.00
10 ¾″ × 14″ DFG eye bolts	125.00
4 ¾″ × 24″ DFG eye bolts	160.88
30 ⅝″ × 15″ DFG eye bolts	522.60
18 ⅝″ × 18″ DFG eye bolts	374.04
6 ⅝″ × 12″ DFG eye bolts	88.32
2 ⅝″ × 24″ DFG eye bolts	61.96
12 ⅝″ × 24″ DFG double arming bolts	72.00
86 ⅜″ × 3″ GV U-bolts w/4 nuts/ cross plates	172.00
42 ½″ × 3¼″ DFG eye lags	180.00
16 ⅝″ × 6¾″ DFG thimble eye lags	127.36
3 spreader bars 18″ × 4″ × ½″	88.20
6 pear-shaped sling links ½″ diameter	44.40
108 heavy galvanized thimbles for ⅜″ cables	97.20
200 heavy galvanized thimbles for 3⁄16″ cable	60.00
24 square DFG washers for ¾″ bolts	19.20
24 round DFG washers for ¾″ bolts	5.76
30 round DFG washers for ⅝″ bolts	6.60
3,000 feet of 7 × 19⅜″ GV steel aircraft cable	1,740.00
600 feet of 7 × 193⁄16″ GV steel aircraft cable	150.00
85 net clamps	170.00
85 aluminum dead end clamps	850.00
170 aluminum oval swedging sleeves	30.60
36 feet of aluminum spacer tubing	90.00
270 DFG heavy cable clamps for ⅜″ cable	648.00
30 DFG heavy cable clamps for 3⁄16″ cable	54.00
108 galvanized serving sleeves for ⅜″ cable	125.28
30 DFG ½″ diameter 6″ staples	180.00
3 type II 16′ aluminum extension ladders	258.00
1 type II 20′ aluminum extension ladder	100.00
200 feet of 1⁄16″ galvanized seizing wire	15.00
1,200 feet 3 strand ½″ combo polyester laid rope	1,000.00
100 ft. kernmantel polyester braided rope	120.00
3 5 lb. boxes galvanized twist nails	21.00
3 small boxes galvanized long fence staples	9.00
15 4″ × 6″ × 8′ pressure-treated beam joists	200.00
45 2″ × 6″ × 8′ pressure-treated decking	270.00
70 2″ × 4″ × 12′ for pressure-treated treads	455.00
Total cost for materials	9,099.40
Shipping	400.00
Air travel two persons	600.00
Other travel	100.00
Time spent in shop preparation, planning and ordering	800.00
Total cost of labor for construction	8,400.00
Total price of the main walkway system	$19,439.40

Additional costs that can be incurred for proper use of a walkway system include:

4 ascenders for use as safety devices while climbing	159.92
4 blue water climbing helmets	175.84
4 fudge harnesses	95.84
4 double safety lanyards or 8 regular lanyards	160.00
4 auto locking carabiners	63.84
Sub-total	655.44
Total cost of walkway system and accessory equipment	$20,094.00

Additional traverses to adjacent trees, consisting of two cables and a rope connecting two trees using a Bosun's chair and a trolley pulley with a lanyard, include $370 for the basic set-up equipment, plus chair ($150), extra ascender ($45), trolley pulley ($85), special lanyard ($50), extra carabiner ($30) and 7⁄16″ galvanized screw shackle ($10). Cables and attachment hardware cost approximately $180.00 plus $2.36 per foot of cables and rope plus labor of approximately $300 for an average span. Such traverses could also be set up on a temporary basis using industrial slings made of nylon or polyester webbing, which would cost approximately $130 for the slings and hardware, but only $200 for labor.

This sort of arrangement allows the researcher to sit in the Bosun's chair, tethered to both the upper and lower cables as well as the center rope, while walking to any place on the traverse. Such traverse systems can be conveniently set up in spans up to 30 m in length.