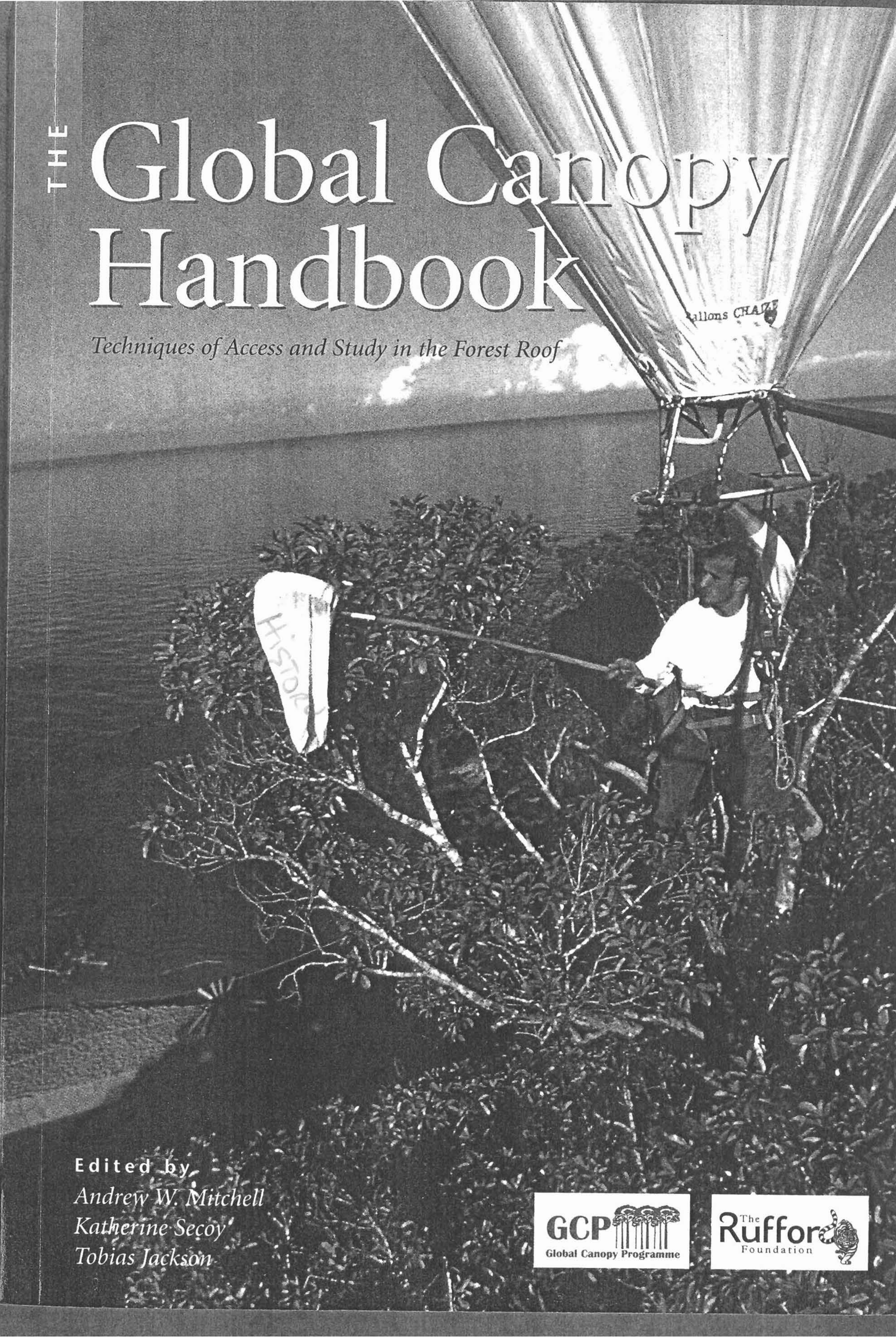
THE

Global Canopy Handbook

Techniques of Access and Study in the Forest Roof



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Canopy Walkways – Highways in the Sky

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RESEARCH in forest canopies has been limited by logistic constraints of access (reviewed in Mitchell 1982, Moffett & Lowman 1995). Over the past decade, several inexpensive techniques have been developed, but they are usually restricted to solo efforts. These include single rope techniques (looked at earlier); ladders (Selman & Lowman 1983, Gunatilleke *et al* 1994); and towers (Odum & Ruiz-Reyes 1970, Zotz 1994). Devices that facilitate research by a group of scientists simultaneously have also been developed, but are usually considerably more expensive (e.g. the raft and dirigible (Hallé & Pascal 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 a common device (see Table 1 in Moffett & Lowman 1995).

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 allow scientists 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 (Figures 1 and 2), are of moderate cost and provide very easy access to users over a relatively long lifespan.

In 1983, one of the world's first canopy walkways was designed on the back of a cocktail napkin in the tropical rain forests of Queensland, Australia (Lowman & O'Reilly, pers. comm.). This was developed as an improvement to our original canopy access technique of solo climbing, which presented a challenge for group research efforts such as biodiversity sampling or Earthwatch supported expeditions using volunteer field assistants. After the walkway in Queensland was successfully funded and built by the Green Mountain Natural History Association, another walkway design was independently constructed in Malaysia (Ilar Muul, personal communication). Other walkways had been built for temporary or restricted research expeditions, but these were the first two permanent walkways designed for multiple use, incorporating ecotourism and research.

In 1992, one of us (ML) set up a non-profit company, called Canopy Construction Associates, with an arborist partner (Bart Bouricius). From this original partnership, the first canopy walkway in North America was constructed in the research forest of Williams College, Massachusetts. This walkway was a prototype, and each phase of the design was carefully costed. The walkway was also created in a modular fashion, with both the bridges and the platforms serving as units that can be replicated to create walkways of all shapes, lengths, and sizes. Since that first construction in a temperate forest, many scientists and researchers have consulted with Canopy Construction Associates for advice, planning and construction of canopy walkways. The process of canopy walkway design and construction are outlined here, with two sample budgets presented for different sized structures.

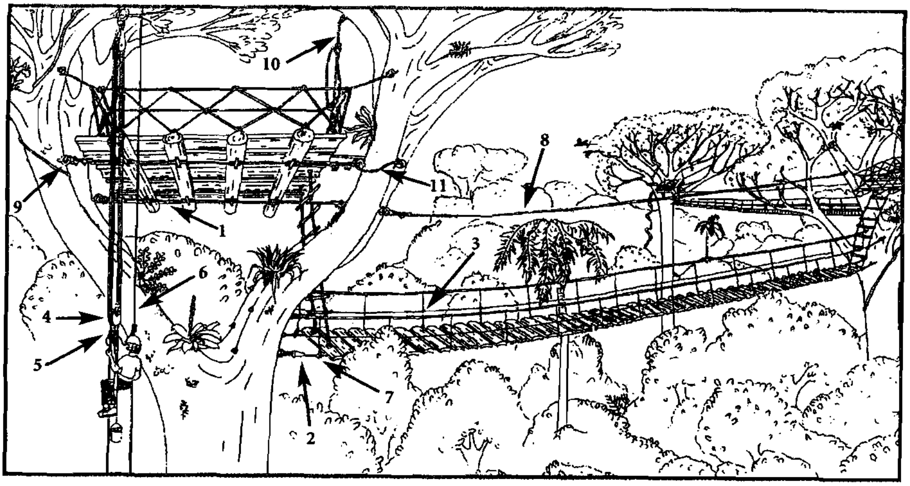


Figure 1 Illustration of the modular system of construction of bridges and platforms. Components shown include:

1. 3/8" stainless steel wire rope (12,000 lb. tensile strength);
2. Strand vice – a hardware item that allows precise measuring and tensioning of a cable while it is being installed;
3. Stainless steel net clamp – clamps two cables together at right angles;
4. Block and tackle – over 10,000 lb. tensile strength;
5. Ascender – device to prevent unintentional slide down rope;
6. Redundant safety rope – makes users feel safer during ascent;
7. Bridge clamp – clamps onto bridge support cable providing a connection to the vertical side cables and prevents unnecessary flexing of cables;
8. Cable for attaching safety lanyard to when walking on bridge;
9. 5/8" x 18" drop forged galvanized steel eye bolt (17,500 lb. tensile strength);
10. Adjustable rope safety lanyard;
11. Redundant cable provides extra security at all major connections.

Methods of Site Selection and Construction

Site selection must integrate 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 branch systems that are conducive to support of platforms
3. selection of a stand of trees with potential for expansion of modules (the minimum operational design consists of one bridge and one platform)
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 species composition and diversity of the forest type

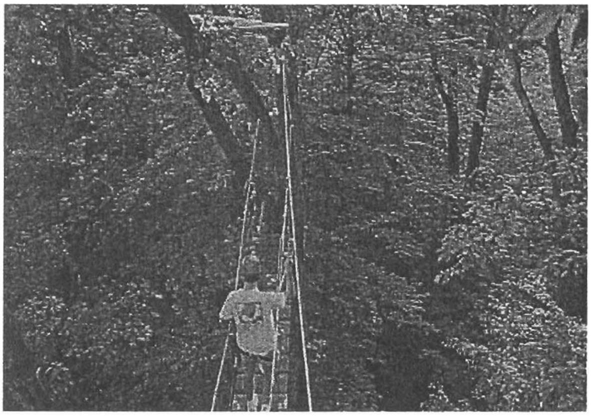


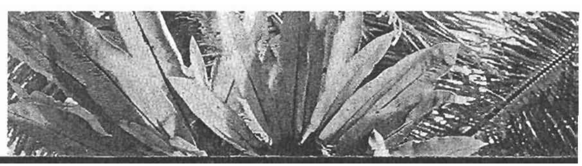
Figure 2
The first canopy walkway constructed in North America, at Williams College, Massachusetts.
Photo: Meg Lowman.

2. placement of 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
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. 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. 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 are 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 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 (Figure 2); 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.



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APPENDIX 1. Budget for Canopy Access Structure at Millbrook School, Millbrook, New York (1995 prices)

This appendix costs out materials for 3 (8' x 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 were 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" x 6" pressure-treated southern yellow pine joists with 2" x 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.

Table 1 Budget for canopy access structure at Millbrook School

MATERIALS

PIECES	DESCRIPTION	PRICE US$
34	*3/4" x 18" DFG eye bolts*	448
10	*3/4" x 14" DFG eye bolts*	125
4	*3/4" x 24" DFG eye bolts*	160
30	*5/8" x 15" DFG eye bolts*	522
18	*5/8" x 18" DFG eye bolts*	88
2	*5/8" x 24" DFG eye bolts*	61
12	*5/8" x 24" DFG double arming bolts*	72
86	*3/8" x 3" GV U-bolts w/4 nuts/cross plates*	172
42	*1/2" x 3 1/4" DFG eye lags*	180
16	*5/8" x 6 3/4" DFG thimble eye lags*	127
3	*Spreader bars 18" x 4" x 1/2"*	88
6	*Pear-shaped sling links 1/2" diameter*	44
108	*Heavy galvanized thimbles for 3/8" cables*	97
200	*Heavy galvanized thimbles for 3/16" cable*	60
24	*Square DFG washers for 3/4" bolts*	19
24	*Round DFG washers for 3/4" bolts*	6
30	*Round DFG washers for 5/8" bolts*	7
3000	*Feet of 7 x 19 3/8" GV steel aircraft cable*	1,740
600	*Feet of 7 x 19 3/16" GV steel aircraft cable*	150
85	*Net clamps*	170
85	*Aluminium dead end clamps*	850
170	*Aluminium oval swedging sleeves*	31
36	*Feet of aluminium spacer tubing*	90
270	*DFG heavy cable clamps for 3/8" cable*	648
30	*DFG heavy cable clamps for 3/16" cable*	54
108	*Galvanized serving sleeves for 3/8" cable*	125
30	*DFG 1/2" diameter 6" staples*	180
3	*Type II 16' aluminum extension ladders*	258
1	*Type II 20' aluminum extension ladder*	100
200	*Feet of 1/16" galvanized seizing wire*	15
1200	*Feet 3 strand 1/2" combo polyester laid rope*	1,000
100	*Feet kernmantel polyester braided rope*	120
3	*5 lb. boxes galvanized twist nails*	21
3	*Small boxes galvanized long fence staples*	9
15	*4" x 6" x 8' pressure-treated beam joists*	200
45	*2" x 6" x 8' pressure-treated decking*	270
70	*2" x 4" x 12' for pressure-treated treads*	455
TOTAL COST FOR MATERIALS		9,100

Shipping	*400*
Air travel, two persons	*600*
Other travel	*100*
Time spent planning and preparation	*800*
Cost of labour	*8,400*
TOTAL PRICE OF MAIN WALKWAY SYSTEM	19,440

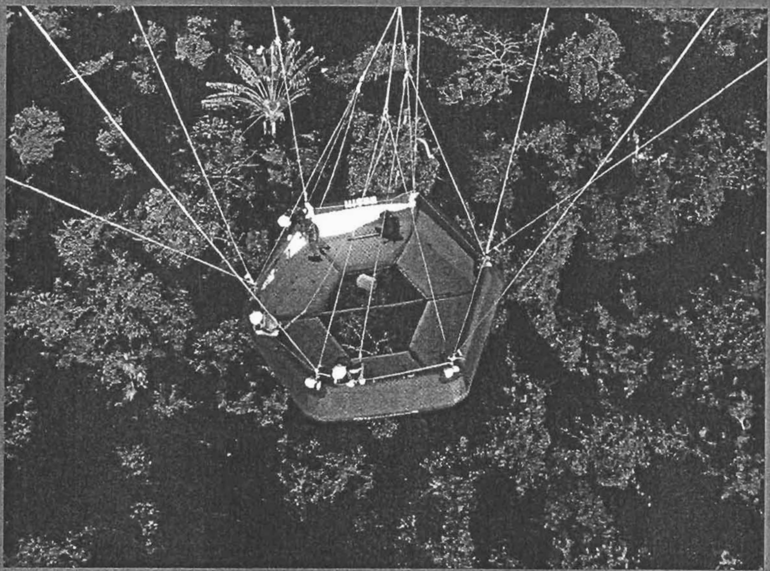
Table 2 Additional costs that can be incurred for proper use of a walkway system

MATERIALS		
PIECES	DESCRIPTION	PRICE US$
4	*ascenders for use as safety devices whilst climbing*	*160*
4	*blue water climbing helmets*	*176*
4	*fudge harnesses*	*96*
4	*double safety lanyards or 8 regular lanyards*	*160*
4	*auto locking carabiners*	*64*
Sub-total		*656*
TOTAL COST OF WALKWAY SYSTEM AND ACCESSORY EQUIPMENT		20,100

KEY: DFG=drop forged galvanized GV=galvanized

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.



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