SUCCESSFUL INTRODUCTION OF VEGETATION ON DREDGE SPOIL

by

K.W. DANCE, SENIOR BIOLOGIST
GARTNER LEE ASSOCIATES LIMITED

and

A.P. SANDILANDS, BIOLOGIST
ECOLOGISTICS LIMITED

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K.W. DANCE, GARTNER LEE ASSOCIATES LIMITED

MARKHAM, ONTARIO

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A.P. SANDILANDS, ECOLOGISTICS LIMITED

WATERLOO, ONTARIO

ABSTRACT

A programme designed to enhance plant colonization of pond dredge spoil is described. Objectives were: to document results of direct introduction of selected plant species on dredge spoil and a newly created pond margin, to document species succession over a five-year period, and to document factors which influenced succession. Wetland and aquatic plants were introduced from local, wild stock sources. Introduction methods included: transplanting, planting wands, broadcasting seed and planting seed. Taxa which flourished include: Giant Burreed, Common Cattail, Broad-leaved Arrowhead, Purple Loosestrife, Bidens cernua, Cocklebur and Willow species. Factors affecting success of marshland plant introductions are discussed.

INTRODUCTION:

Basic principles of wild marshland vegetation introduction have been known for several decades (Lamoureux 1957, Kadlec and Wentz 1974). Some use has been made of this knowledge by waterfowl marsh managers and in efforts to reclaim dredge material (Newling 1981) and slurry impoundments (S. Yaich pers. comm. 1984). Much of the dredge spoil work has been in estuarine and marine situations.

Kadlec and Wentz (1974) indicated that well documented case studies of both experimental and operational marsh planting efforts were required to develop guidelines which would improve future planting success.

Natural invasion of a full variety of wild species on disturbed lands may be slow (Bradshaw and Chadwick 1980), although exceptions have been reported in certain freshwater marshes e.g. Smith (1978). Also, since natural succession may not result in vegetation patterns and species most desirable from fish and wildlife habitat, aesthetic and recreation points of view, human intervention is recommended in some instances (Eleuterius and McClellan, 1976).

This paper describes results of freshwater marsh plant introduction in an urban park setting. The programme was designed to reclaim lands which were visible from yards of several dozen expensive homes. Thus, there was a need to hasten and direct vegetation succession.

STUDY OBJECTIVES:

The three objectives were:

- to document results of direct introduction of selected plant species on dredge spoil and a newly created pond margin,
- to document species succession over a five-year period, and

- to document factors which influenced succession.

SETTING:

This study was conducted in West Heights Park, located on the western margin of Kitchener, which is situated in Southwestern Ontario. The mean annual growing season here is 200 days (Brown et al.1980).

Figure 1 shows the park, pond and adjacent houses in 1983. The 0.70 ha pond is somewhat pear-shaped, with the stem end pointing north. A small temporary pond is located 30 m to the south of the main pond.

HISTORY OF MANAGEMENT:

The study area was developed as a residential subdivision during the last ten years.

The pond and lands immediately adjacent were an open space dedication but underwent little development as they constitute a passive recreation area. The park is administered by the Department of Parks and Recreation, City of Kitchener.

Environmental investigations of the pond begun in 1978, were designed to determine the magnitude of water quality problems in the large pond and to recommend remedial measures (Dance 1979, Dance 1981). Dredging of the pond, rehabilitation of the newly created basin, and reclamation of dredge spoil were three major components of the plan to improve the pond environment.

The pond was dredged using a drag line and spoil was placed on the banks behind straw bale dikes, see Figure 2. Dredging occurred in September 1979 and revegetation of the pond margin began in late October of that year.

FIGURE 1: THE STUDY AREA, SEPTEMBER 1983.

FIGURE 2: THE DRAG LINE AND SPOIL PILES, 1979

REVEGETATION PLANNING:

A plan was developed to ensure rapid, directed revegetation of areas disturbed by dredging. The plan was designed to attain the following objectives at this site:

- to hasten revegetation of pond basin and margin;
- to influence species present:
  (a) to achieve a mix of aesthetic appeal in terms of form and colour;
  (b) to provide fish and wildlife food and cover;
- to introduce "desirable" species so that weeds would not become dominant;
- to introduce aquatic species which would compete with algae;
- to stabilize pond margin soils.

Elements of the revegetation plan included attention to:

- concerns and opinions of local residents;
- involvement of a landscape architect to integrate the pond revegetation efforts with that of upland portions of the park;
- use of local wild plant stock;
- planting in locations where environmental requirements of the species would be met;
- timing of revegetation -- late autumn when soils were moist, temperatures cool, propagules were available and certain plant structures were dormant;
- placing straw mulch on dredge spoil once it had dried and was shaped;
- testing soil conditions prior to seeding upland areas.

VEGETATION INTRODUCTIONS:

Most of the plant introductions were made in October 1979, shortly after dredging had been completed. A few additional introductions were made during the growing season of 1980.

Table 1 summarizes the methods used to encourage establishment of each introduced taxon. Plants are listed in taxonomic order according to Fernald (1950). Several taxa were transplanted as whole plants, others were introduced by planting or broadcasting seed and others such as the Willow and Red-osier Dogwood were introduced as wands.

All stock was gathered from the wild in locales within 40 km of West Heights Pond. Whole plants and wands were transported in moist soil and were reintroduced immediately at West Heights. Seed which was planted was introduced within a few days of being collected. Seed for broadcasting was collected up to three weeks ahead of application by hand. None of the seed was treated. Dead stalks of Purple Loosestrife and Narrow-leaved Cattail which contained seed were pushed vertically into the soil in several locations around the pond margin. It was reasoned that seed would be released to the pond environment through natural processes.

The basic principle of the seed broadcasting technique was to make wild seed of desirable species, for which suitable conditions would exist, available immediately.

Numbers of plants or propagules were recorded for the transplanting and planting activities. The amount of seed for broadcasting was not measured but was described qualitatively.

Intentional introduction of marshland vegetation was confined to a band approximately 4 m wide around the pond, although wind may have spread seed a greater distance.

TABLE 1: INTRODUCTION METHODS BY SPECIES

PLANT SPECIES	INTRODUCTION METHOD(S)
Common Cattail	Transplant
Narrow-leaved Cattail	Seed
Giant Burreed	Transplant, seed broadcast
Water Plantain *	Seed broadcast
Broad-leaved Arrowhead	Seed broadcast (1979), transplant (1980)
Common Reed Grass	Transplant
Larger Blue Flag *	Transplant, seed planted
Sandbar Willow	Wands
Shining Willow	Wands
Bullhead Lily	Transplant (1979 and 1980)
Purple Loosestrife	Seed broadcast
Red-osier Dogwood *	Wands
Swamp Milkweed *	Seed planted & broadcast
Blue Vervain	Seed broadcast
Clotbur	Seed broadcast
Bur Marigold *	Seed broadcast

* Species present on the treated area prior to dredging.

Species arranged in taxonomic order according to Fernald (1950).

MONITORING METHODS:

Maps were prepared in the field which showed the location and number of plants or propagules introduced. Areas treated by broadcasting were also mapped. Thus, there was a basis for monitoring the success or failure of the 1979 introductions.

In September 1980, another mapping was completed which documented the numbers and variety of marshland and aquatic species which had become established. Brief visits to the study area were made during 1981 and 1982, at which time descriptive notes were recorded. In September 1983, another major mapping and counting effort was completed using methods similar to those employed in 1980. In June and July 1984 the site was visited to determine if any major changes in the vegetation complex had occurred since the previous year.

The 1983 inventory also involved preparation of species lists for the pond and littoral area, the backshore and the small pond to the south. The density of species within seven 0.25 m^2 quadrats was also determined along the SW margin of the pond where the greatest effort had been expended on introducing vegetation.

Numbers of study plants were determined only for the area where we introduced plant material. Numbers of species such as Cattail, Burreed and Bullhead Lily were determined by counting main stems or clumps.

The present analysis is a qualitative assessment of the fate of introduced taxa. Other data and observations (not presented in this paper) are cited to aid in interpretation.

As noted in Table 2, for species which were introduced using two or more methods, one of which was broadcast seed, it was often not possible to attribute numbers present to a specific introduction technique.

RESULTS AND DISCUSSION:

In September 1983 West Heights pond and littoral area supported 47 species and 66 species were found on the backshore area. Both of these areas had been extensively disturbed by dredging and by piling of dredge spoil, see Figure 2. Fifty-seven plant species were found growing in and around a small pond 30 m south of the study pond. Of these, 19 species were not present around the large pond.

Table 2 indicates changes in relative abundance of 16 pond and marshland species which we intentionally introduced following dredging. Six of these species (marked with an asterisk in Table 1) occurred prior to dredging or were growing around the small pond in 1983. None of the remaining ten species which were new to the area, dispersed from the north pond to the south pond during the last 5 years.

Discussion of plant introduction results is organized by technique.

FIGURE 3: INTRODUCED BURREED AND WATER PLANTAIN, 1980.

Transplant: The 22 Common Reed Grass plants which were transplanted appeared to have died in 1980. But in 1983 and 1984 four stalks of the species were found.

Survival of transplanted Common Cattail and Giant Burreed whole plants was excellent. Table 2 indicates that the 89 Burreed stems tripled in abundance by September 1980 and multiplied more, three years later. Figure 3 shows a Burreed stand in 1980. The Cattail stems more than doubled in number between 1980 and 1983. For both species vegetative propogation has been responsible for the increased stem group number.

Burreed and Cattail beds have assisted in stabilizing the shoreline and have provided food and cover for wildlife. Lamoureux (1957) and Yaich (pers. comm.) also report that these taxa perform these functions.

Arrowhead propagates by tubers and seed. Tuber or whole plant transplants are the recommended introduction methods for Arrowhead (Lamoureux 1957, Yaich pers. comm.). Experiments in 1978 proved that whole plants could be successfully transplanted to West Heights Pond. These plants were presumed buried during dredging. Seed was scattered in autumn 1979 and resulted in the Arrowhead patches present in July 1980. Extensive patches of Arrowhead present in 1981 along the southern end of the dredge area are thought to have become established from seed.

Bullhead Lily was also introduced as a whole plant. Introductions in 1979 failed because the bouyant roots floated free from the bottom. During 1980 fourteen more were planted into heavy clay soils. These plants have flourished and spread vegetatively.

Wands: Three species: Red-osier Dogwood, Sandbar and Shining Willow were introduced as wands which were stuck in moist soil around the pond margin. Approximately one-third of the Willow wands were flourishing in 1983. Many which did not survive had been broken by children. The Dogwood wand

TABLE 2: SPECIES ABUNDANCE AT INTRODUCTION, IN 1980 AND 1983

Method and Species	Amount Introduced		Total Number Present	
	Nov. 1979	Sept. 1980	Sept. 1980	Sept. 1983
Transplant				
Common Cattail	39	0	42	91
Giant Burreed	89	0	323	583*
Broad-leaved Arrowhead	0	2	29*	300+*
Common Reed Grass	22	0	0	4
Larger Blue Flag	12	0	10*	3*
Bullhead Lily	15	14	14	23
Wands				
Sandbar Willow) Shining Willow	75	0	33	28
Red-osier Dogwood	90	0	6	0
Seed				
Narrow-leaved Cattail	Thousands	0	0	0
Giant Burreed	Hundreds	0	hundreds	P
Water Plantain	Thousands	0	100+	33
Broad-leaved Arrowhead	Hundreds	0	29*	300+*
Larger Blue Flag	Dozens	0	10*	3*
Purple Loosestrife	Thousands	0	P	46
Swamp Milkweed	Hundreds	0	P	3
Blue Vervain	Hundreds	0	1	17
Clotbur	100±	0	7	25
Bur Marigold	Hundreds	0	84	204

NOTE: * Total number present results from transplant plus seed introductions.

P Present but no precise count.

introduction faired poorly, probably because the locations where they were placed became flooded once pond levels had stabilized. Bradshaw and Chadwick (1980) recommend hammering stakes of young Willow into damp soil, in spring, as a means of restoring quarries.

Seed: Narrow-leaved Cattail is the only species which failed to establish itself. Although Kadlec and Wentz (1974) indicate that wind-dispersed Typha seeds are responsible for quick establishment on newly exposed wet substrates, the seed introduction method was probably a poor choice for this species. Transplanting of root stock would probably have been more successful.

Burreed and Arrowhead seed was applied in 1979. Extensive beds of small individuals of both of these species were observed in 1981 along the east and west shores of the pond, south of the area which had been actively revegetated. Most of these patches had disappeared by September 1983. Muskrats and Mallards are suspected to have consumed these plants. Both plant species are valuable waterfowl and muskrat foods (Lamoureux 1957). Along the northern two-thirds of the pond Arrowhead abundance increased an order of magnitude between 1980 and 1983.

The remaining seven species were introduced using seed only. All of these species except Purple Loosestrife and Clotbur were present in the study area prior to dredging.

Water Plantain: Thousands of seeds were scattered on the soil surface. In 1980 over 100 plants were present. The mass of tiny white flowers on the left side of Figure 3 are those of Water Plantain. This species was particularly obvious along the northwest corner of the pond in 1980. Water Plantain persisted but it was not as obvious or abundant in 1983.

Water Plantain seed apparently must be submerged to induce germination and seed of this species is able to remain viable under water for years (Croker and Davis 1914). This species may become more abundant in future

years if some of the original seed still remains in the seed bank.

Larger Blue Flag: This species was re-established in small numbers. Whether seed or transplanting was responsible is not clear. In 1983, it was difficult to locate among the tall grasses but at least three clumps were present. Since these plants require direct sunlight it may suffer from shading by grasses.

Lamoureux (1957) recommends propagation by rootstalk. Elsewhere we have been successful in establishing Iris versicolor by planting wild seed in the springtime.

Purple Loosestrife: This large colourful plant has become established from seed. In 1983 46 individuals of this species were present. It was growing in at least three locations around the pond in 1980 but a precise count was not made.

Swamp Milkweed: Although it was present in the seeded area in 1980 and 1983 the data available do not allow a precise determination of population trends.

Blue Vervain: One plant was observed in 1980, but 17 were present in 1983.

Clotbur: Approximately 100 seeds of this annual were collected and scattered on the dredge spoil in 1979. Seven plants were present in 1980 and 25 were present in 1983. This plant appears to tolerate trampling.

Bur Marigold (Bidens cernua): This colourful annual has more than doubled in abundance between 1980 and 1983. It was present in considerable quantities on the mud ring surrounding the pond prior to dredging.

Table 2 and quadrat data (not presented here) indicate that many of the species which were introduced by broadcasting seed are not numerically abundant. These species do, however, add diversity and colour to the pond margin vegetation complex.

SPECIES SUCCESSION:

Succession is used here in a broad sense to mean changes in plant species composition and abundance in the treated area.

The present discussion briefly addresses factors which are thought to have influenced succession of the marshland vegetation community at West Heights Pond during the past five years.

Seed Bank: Undoubtedly, the dredge spoil contained seed. The more widespread occurrence of certain rush and bulrush species after dredging may have resulted from germination of seed contained in the dredge spoil. Spreading of soil from wetlands has been recommended as a method for establishing vegetation on slurry impoundments (Yaich pers. comm).

Moist soil conditions trigger germination of seeds of several species of freshwater marsh plants present in seed banks (Smith and Kadlec 1983). Dormancy and after ripening in certain species will influence "recruitment" of those species into the West Heights plant community.

Seed Dispersal: A plant list for the small pond 30 m south of the treated pond has revealed that numerous wetland species have not spread from there to the large pond. Similarly, none of the ten species absent from both ponds before direct introduction to the large pond have spread to the south pond.

Brief inventories of wetland vegetation composition of four ponds within 2 km of West Heights have revealed that species such as Common Cattail, Sandbar Willow and Purple Loosestrife have existed within 1.5 km of West Heights but did not arrive there naturally. The literature indicates that wind, water, animals and man's activities play roles in dispersal of marsh plant seeds (Kadlec and Wentz, 1974).

Competition: We have no hard data on this factor but competition is expected among species arriving on the scene from various sources: human

introduction, seed bank, weeds with effective dispersal mechanisms and so on. By 1984 Reed Canary Grass had become dense and undoubtedly choked out certain other species growing in upland sections of the west bank.

Kadlec and Wentz (1974) indicate that many annuals are adapted for widespread seed dispersal but that perennials will exclude annuals and subsequent competition among perennials will eliminate some species (pp. 196-197).

Shoreline Erosion. Wave action was responsible for local erosion along the pond margin early in the 1980s, before extensive vegetation growth became established. This caused several of the willow wand plantings to be washed away. Planting had been designed to minimize shoreline erosion and succeeded in this aim, in time. Perennial members of the followng families have dense and spreading root systems which stabilize substrates: Gramineae, Cyperaceae, and Typhaceae (Kadlec and Wentz 1974).

Soil Moisture/Water Levels: Since runoff and precipitation falling directly on the pond are the only sources of water for the pond, evaporation causes fluctuation in water levels. Consequently, shoreline soil moisture may vary from year to year and during a particular growing season.

Differences in soil moisture may be responsible for differences in plant communities on the spit during the last two years. For example Xanthium which was numerous on the spit in 1983, was absent in 1984 and Juncus balticus which dominated several quadrats was replaced by Soft Rush. Water Plantain appeared to be more numerous along the damp margins of the pond this July than it was during 1983 when conditions were drier and a narrow band of dry soil separated dense marginal vegetation from the water's edge. Receding water exposes moist soil which provides conditions conducive to seed germination in several freshwater marsh species (Smith and Kadlec 1983).

Trampling: The spit receives heavy foot traffic during dry years and

paths are broken to the pond margin by children attempting to catch frogs and turtles. Willow saplings developed from wands, Burreed, Bidens and Xanthium have been observed to suffer damage from trampling. Trampling has not caused the elimination of any of the introduced species but may have been responsible for loss of certain individuals.

Muskrats, Mallards, Fish: Muskrat food piles which we examined contained Rush, Burreed, Spikerush and Cattail. Muskrat tunnels have been cut into the west bank of the pond, this was not noticed prior to pond dredging. It may be that an improvement in food availability since rehabilitation has increased muskrat population size.

In July 1984, three broods of Mallards were present on the pond. The young were observed feeding on pond margin vegetation. Mallards' diets are known to include a major vegetation component (Bellrose 1976). Ducks feeding in shallow water create turbidity which may have negative effects on plant growth.

During the past three years fish have become a prominent element of the pond ecosystem. Brown Bullheads grow large enough that they provide recreation for young anglers. Schools of Bullheads feeding in shallow areas create turbidity, just as ducks do. Since Bullheads are omnivorous (Scott and Crossman 1973) they may consume roots and seeds of aquatic plants.

Creating food and cover for fish and wildlife was one of our objectives, but we had not anticipated animals as a negative influence on the plants which we introduced. Others have concluded that waterfowl usually do not harm established stands although seedlings and newly invading shoots may be destroyed (Kadlec and Wentz 1974). We observed the loss of hundreds of Giant Burreed and Broad-leaved Arrowhead seedlings in the south end of the pond between 1980 and 1982. Krummes (1940) found that muskrats may "clean-out" established stands of favoured food plants.

In other settings the following factors may affect the success of marshland plant introductions: physical/chemical characteristics of the substrate, water quality and turbidity.

SUMMARY:

As noted by Bradshaw (1983) reconstruction of ecosystems is an environmental problem for which solutions are available and one to which ecologists have an important contribution to make.

Key findings of this study follow:

- Species selection is a key element of any revegetation plan. We were able to create an appealing vegetation complex in an urban residential setting by introducing certain showy species. Other more practical objectives such as shoreline and dredge spoil stabilization and provision of fish and wildlife cover were also achieved by introducing selected species.
- Revegetation under cool, moist late autumn conditions using local wild plant and seed stock was successful.
- Kadlec and Wentz (1974) and Wentz et al. (1974) should be referred to for details of marshland plant introduction techniques.
- Year to year variation in pond margin vegetation composition appears to be considerable. Water level fluctuation and shoreline soil moisture regimes are suspected of being responsible for these differences in plant communities.
- Introduction of Broad-leaved Arrowhead, Purple Loosestrife and Water Plantain by seed succeeded. This may be one of few locations where this has been attempted.
- Factors which we presume affected plant succession at West Heights include: seed bank; seed dispersal; competition; soil moisture/water levels; trampling; muskrats; mallards and fish.

- Ten plant species absent before dredging did not spread from the actively revegetated area to a small pond 30 m away, during the 5-year study period.
- Where marshland species which spread rapidly are required, perennials should be introduced in preference to annuals since the former will spread both vegetatively and by seed. Often seed production is unpredictable and unreliable and seeds may remain dormant for a time.

LITERATURE CITED

Bellrose, F.C. 1976. Ducks, Geese and Swans of North America. Stackpole Books. 544 pp.

Bradshaw, A.D. 1983. The Reconstruction of Ecosystems. J. Appl.Ecol. 20:1-17.

Bradshaw, A.D. and M.J. Chadwick.1980. The Restoration of Land. Blackwell Scientific Publications. Oxford.

Brown, D.M., G.A. McKay and L.J. Chapman.1980. The Climate of Southern Ontario. Environment Canada, Atmospheric Environment Service , Climatological Studies Number 5. 66 pp.

Crocker, W. and W.F. Davis.1914. Delayed germination of Alisma plantago. Bot. Gaz. 58:285-321.

Dance, K.W. 1979. The Urban Pond - Amenity or an Eyesore? Civic Public Works. June: 13-15, 44.

Dance, K.W. 1981. The Park Pond: A Plus or a Problem? Recreation Canada. No. 2:20-27.

Eleuterius, L.N. and H.A. McClellan.1976. Transplanting Maritime Plants to Dredged Material in Mississippi Waters. pp. 900-918. In: Proceedings of the Specialty Conference on Dredging and Its Environmental Impact. American Society of Civil Engineers, New York.

Fernald, M.L. 1950. Gray's Manual of Botany. D. Van Nostrand Company, New York, 8th Edition.

Kadlec, J.A. and W.A. Wentz.1974. State-of-the-Art Survey and Evaluation of Marsh Plant Establishment Techniques: Induced and Natural. Volume I: Report of Research. University of Michigan, Ann Arbor, pp. 231.

Krummes, W.T. 1940. The Muskrat: A Factor in Waterfowl Habitat Management. N.Am. Wildl. Conf., Trans. 5: 395-398.

Lamoureux, W.J. 1957. Aquatic Plants for Fish and Wildlife. Royal Botanical Gardens Tech. Bull. No. 1. Hamilton, Ontario.

Newling, C.J. 1981. Monitoring of Dredged Material Research Program Habitat Development Sites. Dredged Material Research Vol. D-81-1: 2-8.

Scott, W.B. and E.J. Crossman.1973. Freshwater Fishes of Canada. Fish. Res. Bd. Can., Bull. 184. Ottawa.

Smith, H.K. 1978. Habitat Development: An Alternative Method of Dredged Material Disposal. pp. 745-803. In: Proceedings of Symposium on Environmental, Socioeconomic and Regulatory Aspects of Coastal Zone Management. ASCE, New York.

Smith, L.M. and J.A. Kadlec. 1983. Seed Banks and Their Role During Drawdown of a North American Marsh. J. Appl. Ecol. 20:673-684.

Wentz, W.A., R.L. Smith and J.A. Kadlec. 1974. State-of-the-Art Survey and Evaluation of Marsh Plant Establishment Techniques: Induced and Natural. Volume II: A Selected Annotated Bibliography on Aquatic and Marsh Plants and their Management. University of Michigan, Ann Arbor. pp. 190.

Yaich, S.C. 1984. Slurry Impoundment Reclamation. Personal communication to K.W. Dance

APPENDIX 1: COMMON AND SCIENTIFIC NAMES OF INTRODUCED SPECIES

COMMON NAME	SCIENTIFIC NAME
Common Cattail	Typha latifolia
Narrow-leaved Cattail	Typha angustifolia
Giant Burreed	Sparganium eurycarpum
Water Plantain	Alisma triviale
Broad-leaved Arrowhead	Sagittaria latifolia
Common Reed Grass	Phragmites communis
Larger Blue Flag	Iris versicolor
Shining Willow	Salix lucida
Bullhead Lily	Nuphar variegatum
Purple Loosestrife	Lythrum salicaria
Red-osier Dogwood	Cornus stolonifera
Swamp Milkweed	Asclepias incarnata
Blue Vervain	Verbena hastata
Clotbur	Xanthium chinense
Bur Marigold	Bidens cernua

Nomenclature after Fernald (1950).

CLRA

NINTH ANNUAL MEETING CANADIAN LAND RECLAMATION ASSOCIATION

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PROCEEDINGS OF THE NINTH ANNUAL MEETING

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